DEVELOPMENT OF A BASIS FOR A
HAZARDOUS MATERIALS AND
WASTE MANAGEMENT SYSTEM
FOR AIR FORCE CONTINGENCY DEPLOYMENTS

THESIS

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Wright-Patterson Air Force Base, Ohio

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Presented to the Faculty of the Graduate School of Engineering

of the Air Force Institute of Technology

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering and Environmental Management

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Captain, USAF

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Christopher J. West

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Abstract

Increased awareness of the potential for adverse mission impact on deployments, recent experience on such deployments, and Air Force and Major Command interest establish the need for an integrated hazardous materials and waste management system for contingency environments. This research was focused toward establishing a basis for developing such a system. An intensive literature review was accomplished to justify the necessity of the research, characterize the contingency environment, review legal and regulatory requirements, review proper hazardous substance handling and processing procedures, and review existing and new material resources which may be employed in such a system. Further literature review led to the development of a rigorous design methodology for producing such a basis. Employment of the methodology in characterizing the problem, generating and screening alternatives, and grouping of surviving alternatives led to the establishment of a basis for future specification of a hazardous materials and waste management system for contingency deployments. A final recommendation to the Air Force was made which included the coordinated adoption of the management system by Air Staff representatives of the various functional components of a deploying wing. The staffing support of these functions at the Air Staff, Major Command, and support agency level could then take the recommended practical implementation measures, which were generated from the management system basis.

Development of a Basis for a Hazardous Materials and Waste Management System for Air Force Contingency Deployments

Chapter I

Introduction

Background

Over the past fifteen years the Air Force has dramatically increased the emphasis it places on environmental issues. Where in the mid seventies only a minimal amount of environmental administrative work was done by the Air Force, now there is the Air Force's four-pillared strategy concentrating on cleanup, compliance, conservation, and pollution prevention. The environmental restoration budget, responsible for the cleanup of past spills, leaks, and other problems, has increased to more than $500 million with a goal to reduce all high and medium risk sites to low risk sites by the year 2000. Environmental compliance funding has increased to $650 million, and with most of the less difficult problems addressed, increased concentration is being given to the area of pollution prevention with budgets now reaching over $37 million (Smith, 1995: 1).

All Air Force bases have environmental flights responsible for implementing these initiatives and ensuring base operations are conducted within environmental regulation and law. These offices, some of which report directly to wing commanders, are comprised of

ten to over 50 personnel and are supported by counterparts in each major command and on the Air Staff itself. In addition, the Air Force has established AFCEE, the Air Force Center for Environmental Excellence, with headquarters located at Brooks AFB, Texas and regional offices located centrally in other parts of the country.

As a result of the growing capital invested in environmental stewardship the Air Force has seen some success. Numerous awards have been earned in recent years. Perhaps the most noteworthy being that of the President's Council on Environmental Quality for the best planning program in the federal government (Widnall, 1996: WWeb). The number of open enforcement actions has been reduced by over 47% since 1992 (Marchese, 1995: 16). The HAZMart Pharmacy system, a centralized processing of Hazardous Materials in which incremental amounts are distributed to individual units as they generate requirements, thereby preventing shelf time limits from being exceeded, is being implemented Air Force wide. A savings of $30 million in one year at Hill AFB, Utah is attributed to its implementation (Marchese, 1995: 16).

Mission Impacts

Why this concentration of effort on the environment? Certainly public concerns over health and ecological risks have risen in the last 25 years to the point where the environment has become a serious political issue. As a result, numerous laws, regulations, and executive orders have been enacted on local, state, and federal levels with corresponding enforcement agencies, substantial fines, and legal penalties to motivate organizations to comply. In addition, the Air Force wants to maintain trust with the

taxpayers and a favorable perception in the public's minds. Finally, the Air Force is made up of people who are increasingly adopting an environmental ethic as part of their own beliefs and therefore initiate measures simply because "it's the right thing to do." (Bahm, 1996: 1).

Each of the motives cited above serve to motivate the increased emphasis on the environment, but they seem to be a subset of one over reaching goal, that is, to accomplish the Air Force's mission. According to the Air Force Chief of Staff, Gen. Ronald R. Fogleman, "the United States Air Force exists for one reason, and one reason alone -- to fight and win America's wars when called to do so" (Fogleman, 1996:1) The capability to accomplish the Air Force's mission, "to defend the United States through the control and exploitation of air and space" or as more popularly known, "to fly, fight, and win," will be impacted if environmental concerns are ignored. In order to ensure that fines, penalties, operation restrictions, personnel health and morale, and public feeling do not hamper our ability to train, deploy, and fight, the service must address environmental issues.

These environmental initiatives have been implemented in recent years in a relatively stable, peacetime environment at established overseas and stateside air bases. The Air Force, however, is a service which increasingly relies on its ability to quickly deploy aircraft and personnel around the world in order to project air power and provide support in various theaters of operation. As seen from recent engagements in Saudi Arabia, Somalia, Bosnia, Central America, and the Caribbean and in war planning documents for the European and East Asian theaters, personnel can expect to find

themselves establishing contingency operations at locations ranging from established allied air bases to bare bases where they may arrive to find only a runway and water source. Civil Engineers, being among the first to arrive to start large beddown operations, can see even established infrastructures, aided with expedient equipment reserves, quickly become taxed to maximum capacities. Increased operation tempos, heightened threat conditions and mission priorities, and destabilized or non-existent civilian manned institutions which may be taken for granted, create an environment very different from the one in which the Air Force has recently established its environmental management programs and methods.

These differences between the contingency and peacetime environments have led to a relatively minimal amount of effort being expended on environmental considerations by deployed forces. Certainly, immediate mission requirements of extreme importance which arise continuously during deployments demand that many peacetime practices be curtailed. Manpower, infrastructure, and equipment resource constraints which are almost an integral part of any contingency deployment also require commanders to prioritize actions and focus efforts. Civilian manned agencies which make concentration on regulatory compliance a must during stateside peacetime operations, are definitely not expected to be around when the threat of hostilities begins to rise. Finally, the dominant ethic found both in the public and among Air Force personnel during contingencies at times of heightened tensions is to accomplish objectives and minimize losses, thus other considerations must take on a secondary role.

While all of these reflections mandate reduced environmental efforts during deployments, the same primary motivation for the Air Force's peacetime expansion of

such efforts must be applied to the contingency scenario. That is, are there environmental management measures which, if implemented during contingencies, will increase the Air Force's ability to accomplish the mission which is the objective of the deployment? The converse of the question must also be asked; are there environmental considerations which, if ignored, can severely impact the ability of the Air Force to accomplish its wartime mission? While immediate mission impact is the consideration which first comes to mind, one must also ask if there will be a longer term, broader mission impact if the Air Force is required to cleanup past problems before it can effectively end a deployment or if it is going to be continually required to spend cleanup funds in poorer host nations.

Objectives

It is becoming increasingly clear, as will be detailed in the literature review for this thesis, that the answer to these questions regarding mission impact is "yes," and the concerns seem to be concentrated in one area. Sewer, water, air, and noise permits, conservation efforts in the areas of wetlands preservation and biological diversity, and legally mandated environmental assessment and facility requirements, comprise a large part of the peacetime work of a wing's environmental flight; however, it seems that the proper storage, transportation, use, and disposal of hazardous materials and the subsequently generated hazardous waste make up the greatest recurring part of the ongoing mission of the organization.

Hazardous materials and waste management relates to each pillar (compliance, cleanup, conservation, and pollution prevention) of the Air Force's overall environmental

strategy. The wing's aircraft, vehicles, and equipment cannot function or be maintained without these critical materials and therefore when wings deploy they continue to generate a demand for them. Improper management of these materials, and wastes can readily lead to significant personal health, fire hazard, and equipment problems. While U.S. or host nation legal requirements mandate many of the functions of a wing's environmental flight, proper hazardous materials and waste management is compelled by its direct potential mission impact which can be felt not only at home but also on deployments and therefore should be a primary consideration in deciding which environmental efforts, if any, should be taken along into the field.

Recently, Air Force leadership has begun to search for and develop management solutions to the problems of storing, transporting, using and disposing of hazardous materials. The concept of a hazardous materials pharmacy has now been implemented at most bases. Under the HAZMart system, wing supply organizations centrally store hazardous materials, maintain regulatory safety material and in some cases computerized inventory information, and then distribute the materials and the information to requiring organizations on an incremental basis. Under previous systems in which individual wing organizations procured hazardous materials along with other items through the supply system, large increments were stored near the site of their use. As a result of larger increments being stored by individual organizations, trends of shelf-lives expiring before the material could be used were consistently noted. As a result of expired shelf-lives unused hazardous materials suddenly became hazardous wastes, incurring the capital and managerial costs associated with storage and disposal (Marchese, 1995: 16).

While regulatory requirements for hazardous materials and waste management may not be present on deployments, the potential safety hazards related to, and the dependence of Air Force resources on, such materials remains. The implementation of a management alternative at home to address such issues motivates one to analyze the storage, transportation, use, and disposal of hazardous materials when deployed, to determine if a management alternative exists that will minimize potential adverse mission impacts while meeting the constraints unique to the contingency environment.

The objective of this thesis is to develop a basis for a management system that will safely manage the life-cycle flow of hazardous materials and wastes during Air Force contingency deployments, primarily minimizing potential adverse mission impacts, and secondarily minimizing post-deployment impacts. The literature review will serve to determine if such a system is even necessary, what constraints might be placed upon such a system by the contingency environment, what regulations, laws, and subsequent underlying safety concerns apply in the field, and finally what technological resources might be employed to support such a system.

Given the qualitative nature of designing and demonstrating the effectiveness of a system, a component of this thesis research is the development of a rigorous methodology, supported by its own literature review, of selecting constraints and then evaluating generated alternatives. The actual evaluation of alternatives and construction of a management system as a whole then follows, resulting in a final basis for further development of a hazardous materials and waste management system for Air Force contingency deployments.

Chapter II

Literature Review

Overview

The information in this literature review is organized into five major sections, each with its own sub-sections. Each major section supports one of the five distinct purposes already briefly described in the previous chapter. The first section examines recent Air Force planning, deployment and post deployment trends and anecdotal evidence relating to the management of hazardous materials and wastes, in an attempt to evaluate the necessity of developing management initiatives addressing the issue. Next, existing literature regarding contingency planning, deployment, organization, construction, supply systems, and other functions is examined along with recent Air Force experience to characterize the attributes of the environment under which a management system may be required to perform. The third section will examine existing laws and regulations which may apply to operations in the field. This will be followed by a section detailing the general safety requirements for processing hazardous substances in the workplace in order to determine what measure may be implemented by Air Force organizations on deployments. Finally, the last section examines existing, new, and evolving technological resources which may be employed to support the management of hazardous materials and wastes.

It should be added that some of the examined literature and consultation do not fit neatly into the above distinctions. In particular, the qualitative nature of this thesis

required some research into approaches used to accomplish program-system design and development. These efforts are discussed in chapter three, where they support the chosen methodology used in the design process.

The Necessity of the Research

The undertaking of the design process is usually stimulated by an initial needs analysis, used to verify the existence of recurring problems, difficulties, and unmet requirements. (Ostrofsky, 1977: 32). Motivation for this research stems from three main sources: an increasing awareness in the military of the broad impact of the environment on mission capability, anecdotal evidence of past management problems with hazardous materials and wastes during Air Force deployments, and a growing Major Command and Air Staff interest in the issue.

As environmental initiatives have increased in scope and funding in the peacetime military here in the United States, individual and institutional awareness has risen substantially. Leaders and planners are now more aware of the potential for environmental concerns to impact mission capability. The concentration on these issues at home has naturally led to increased focus and discussion on their application in the field.

The intersection of environmental considerations with those of deployments leads to a variety of perspectives. Army Brigadier General Joseph G. Garrett, writing as Director of Strategy, Plans, and Policy for the Office of the Deputy Chief of Staff for Operations and Plans, stresses that:

> "…environmental restraints should not increase the cost of victory to friendly forces, the probability of a prolonged conflict, or the probability of an unfavorable outcome" (Garret, 1995: 6).

The main focus of Garrett's paper is in reinforcing the understanding that commanders must be primarily concerned with winning and minimizing losses, while reducing collateral damage.

A major portion of literature is centered on the concept of environmental security. One such example is Army Brigadier General Joseph C. Conrad who begins to address the environment in combat operations from the perspective of resource needs motivating conflict and being a central part of the logistical supply chain of military forces. Conrad advocates incorporating environmental security considerations into operational doctrine, as the resources of the modern world become increasingly strained, but goes further in citing classic operational doctrine and the fact that military forces are dependent on the land on which they fight. Numerous examples of poisoning water and food supplies for wartime purposes are cited, ranging from ancient times through the Iran-Iraq war. (Conrad, 1995: 45).

Most of the convergence of thought, and literature, on environmental and contingency issues after Operations Desert Shield and Desert Storm regards Iraq's dumping oil in the Persian Gulf and igniting oil well fires in Kuwait. The focus of this research begins to appear in some of the cited lessons learned from the conflict. In its after action report, the U.S. Army Engineer School states:

> "No clearly defined environmental guidance was issued during Operations Desert Shield and Desert Storm. It was unclear what standards had to be followed for the construction of facilities to accommodate troops, materials, and equipment..." (USAES, 1993: 52).

Anecdotal evidence from the gulf after the war tends to reinforce the notion that procedures need to be further clarified with regard to hazardous materials and waste management. According to interview of several sources, in 1993 at Dhahran Air Base in Saudi Arabia, two F-15 aircraft on alert status, responsible for enforcing the no-fly zone over southern Iraq, were replenished with spent hydraulic fluid. It seems used fluid was stored in the alert hangars in the same drum containers as the original supply. The mistake, caught a few hours later, had the potential for seriously compromising the air worthiness of the fighters and thus possibly the no-fly zone enforcement. A makeshift base wide collection system for hazardous wastes, consisting of a junior officer and an enlisted person driving a flatbed truck from collection points to a central storage location was immediately instituted while off-base disposal was contracted (Thomas, 1996: 1).

Another incident occurred near the end of Operation Restore Hope, as political considerations called for a rapid end to a US presence in Somalia. Air Force civil engineering personnel in the process of preparing for evacuation of the Mogadishu Airport, apparently under the instruction of a company grade officer, buried drums and cans of unknown substance (probably contaminated diesel fuel). Leaks were quickly detected in the water table by remaining forces, who traced the source to the buried containers and demanded removal and cleanup. As a result, evacuation operations were incomplete and delayed as a small crew was required to dig out the containers, while repeated testing and negotiating eliminated the need for further cleanup (Keel, 1996:1).

Another example of past problems, from the author's personal experience, is found throughout the collocated operating bases (COB's) in the Republic of Korea. Should hostilities break out on the peninsula, plans call for the massive deployment of Air Force

personnel and aircraft to several of these host nation bases. In attempting to site and drill water wells to support such forces it was repeatedly found that all sites were contaminated, primarily with volatile organic compounds, probably due to past fuel spills. In this case commanders would be forced to decide between having up to 20,000 personnel consume the water, under the presumption that consumption on a relatively short term basis would be a tolerable, safe exposure to the contamination, or relying on the continuous logistical supply of bottled water. The prevalence of the groundwater contamination at the COB's indicates the presence of consistent spill and leak problems during the recurring deployments and exercises in Korea.

Central Command (CENTCOM), in particular, is faced with the difficulty of proper disposal of hazardous wastes because the usual military institution responsible for procuring such disposal, the Defense Reutilization and Marketing Office (DRMO), does not operate in this theater as it does in others. Instead, contracting hazardous waste disposal occurs on an installation by installation basis under Army supervision. As most countries in the theater are not fully modernized or even concerned with proper disposal, such services can be difficult to find. Repeated cases have been cited in discussion with CENTCOM and Air Force Civil Engineering Support Agency (AFCESA) personnel where drums have accumulated at various remote installations without proper labeling because no adequate means of disposal is available. The only viable recourse is to ship the containers via air transport to a more established installation. Given both the perceptions and regulations regarding transport and acceptance of unknown materials, this feat may require substantial involvement by high ranking commanders (Smith, 1996:1).

Stories like these and others, along with the increased focus such issues are receiving in contemporary military literature, have led both the Air Staff and the Major Commands to begin to address the issue. It was interest from Air Mobility Command that initially called for this research, now sponsored by Air Combat Command as part of their pollution prevention efforts. The Air Staff is currently in the process of drafting the Air Force Environmental Handbook for Contingency Operations which will describe applicable laws, policies, duties, programs, and risk management techniques in a broad, common sense manner for commanders and personnel in general.

MAJCOM and base planners are beginning to address contingency environmental issues in a general form also, raising explosive quantity-distance concerns for hazardous material storage locations and concerns regarding processing and storage of hazardous wastes at Base Support Planning (BSP) meetings. Perhaps the most forward thinking result of these efforts was seen in the planning of a recent exercise. As part of Exercise Bright Star '95 a Hazardous Material and Waste Management Plan was developed by the 366th Civil Engineering Squadron prior to the deployment. The main functions of the plan included siting and sizing a Hazardous Materials Storage facility. The area served as a central storage point for hazardous materials and wastes and would be manned by civil engineering personnel. General procedures for turn-in, labeling, segregation, and turnover to disposal contractor were also described (see Appendix A).

Recent trends in increased military environmental awareness have naturally intersected discussions of contingency issues. As a result, a growing body of contemporary military articles and white papers are addressing the environment's role in combat operations, primarily on the subject of collateral damage and enemy vulnerability.

Published lessons learned and anecdotal evidence suggest that hazardous materials and waste management need to be given serious attention because improper management can have potential adverse impact on mission capability. Both the Air Staff and the Major Commands are showing a heightened interest in the issue and are beginning to provide personnel with some guidance. The point being reinforced by such increased emphasis is that improper management of hazardous materials and wastes can affect the Air Force's mission capability. Both experience and forethought suggest the necessity of a management system which adequately addresses these issues and can be suitably implemented in the contingency environment.

The Contingency Environment

The purpose of this portion of the literature review is to briefly describe deployed conditions which personnel may encounter, in order that the general constraints, which any management system must satisfy if it is to function in a contingency environment, can be established later. The main source of information regarding contingency conditions and expedient methods from a facility and infrastructure construction perspective are the six volumes of Air Force Pamphlet (AFP) 93-12, which will serve as the primary basis for this review. In attempting to characterize the contingency environment, one must also rely on general institutional and personal knowledge and the broad background of literature describing past deployment experiences. As a result, some the review that follows is a restatement of common Air Force knowledge and not traceable to a specific source. A framework for the instruction and analysis of deployed operations used regularly in literature and discussion is the timeline of pre-deployment, deployment, sustainment, and

redeployment and will be used here to characterize the situations Air Force personnel may encounter in the field.

Pre-Deployment

The primary objectives in the pre-deployment phase are gaining knowledge about the deployment location and developing plans for the introduction, organization, and support of incoming forces. Deployment locations and installations cover a wide range of scenarios. AFP 93-12 vol. 6 describes two major categories of operational theater air bases, the initial air base and the temporary or semi-permanent air base. The initial air base

> "...provides minimal, austere facilities intended for operations under six months, but may later require upgrading with more substantial or durable construction to become a temporary/semi-permanent air base"

Vol. 6 goes on to break down the initial air base into the basic drop/extraction zone used for the delivery and recovery of troops and heavy logistics, requiring nothing more than "flat, stump free terrain," and expedient airfields, ranging from the assault airfield which

> "...provides a landing area for assault transports...needed for only a few days with only ten sorties or for three months with up to 200 sorties a day with a surface consisting of unprepared earth with only clearing and leveling,"

to the actual bare base, described as having

> "...a runway, taxiways, and parking areas adequate for the deployed force, and possessing an adequate source of water that can be made potable and mobile expedient facilities."

The temporary or semi-permanent air base is described as providing

> "facilities to the full operational standard for sustained operations for time periods extending up to 24 months, or possibly longer. The facilities are

below peacetime standards, but provide reasonable safety and make operations practicable under adverse operating conditions" (AFCESA 6 1993, 1-2).

Vol. 1, Force Beddown, of the student outline guide used in teaching new Air Force Civil Engineering officers combat engineering breaks down deployment sites into the following five major categories:

> Main Operating Base (MOB) - an air base with all essential buildings and facilities and an in-place civil engineering force that may require augmentation.
>
> Collocated Operating Base (COB) - an active allied base that can be used to beddown augmenting forces.
>
> Limited Base (LB) - an air base that is austerely manned but may have a small force for special operations. These bases can receive deployed forces but require civil engineering augmentation to support expanded operations.
>
> Standby Base (SB) - an austere base designed for wartime use that has an airfield large enough for an operational wing. These bases generally have the same facilities as a limited base, but they are in a caretaker status.
>
> Bare Base (BB) - a base that has at least a runway, taxiways, and parking areas adequate for the deployed force and a source of water that can be made potable (SOCES 1 1993, A-2).

The point of restating these various classifications of potential deployment sites is to show the wide range of scenarios with which planners are confronted. In general, War and Mobilization Plans (WMP) or Operation Plans (OPlans), which evolve as political, geographical, intelligence, and other factors change or are developed in reaction to more sudden changes, detail the overall joint services' objectives and strategies as determined by high ranking leadership. These plans designate the phased deployment of specific Air Force wings and squadrons to specific installations in support of strategic objectives. As

leadership initiates or adjusts WMPs, Base Support Plans (BSPs) are drawn up by Major Command staff personnel representing all of the various wing functions working in conjunction with the leadership of the designated deploying forces.

It is the author's experience that the heart of most BSP's are drawn up in short, one to two week conferences held by the Major Command or Numbered Air Force logistics staff in conjunction with the leadership of deploying units at the actual installation in question. According to the various wing functions, BSPs are broken into several parts addressing air operations, intelligence, engineering, supply, fuels, transportation, personnel, communications, aircraft maintenance, munitions, aircraft parking and off-loading plans, meteorology, medical, security, and services. These plans detail and prioritize exactly which tasks which must be accomplished to make the installation capable of accomplishing its wartime mission and detail the specifics of aircraft parking plans, personnel beddown locations, wing function locations, base defense, and base operations. Another function of the BSP is to identify which resources can be found on base, stored in pre-positioned War Readiness Material (WRM) reserves, and which resources will have to be shipped to the installation.

BSPs themselves evolve overtime through recurring conferences and staff work in response to alterations in the overall war plan and the variety of other sources of changes to requirements and resources in forward locations. As immediate wartime tasks are defined and prioritized, a Timed Phased Force Deployment Listing (TPFDL) is developed and adjusted in support of the WMP and BSPs. The TPFDL designates the transportation logistics for specific deploying units and resources and the order and timing of their arrival and off loading.

It should be noted that the security classification of various portions of BSPs differs from theater to theater, indeed even from base to base. Air operations, parking plans, and security procedures are always classified; usually engineering, supply, and other portions are available to all Air Force personnel who may require them, though sometimes even these are classified as secret or top secret. WMPs and TPFDLs are generally classified as secret or top secret.

The various wing functions and resources have been broken into specifically sized, generally unclassified, deployment packages or Unit Type Codes (UTCs). Depending on estimates of requirements at the deployed location planners developing the TPFDL can call for packages designed and sized appropriately for the task. The UTCs for these teams detail specifically by AFSC (Air Force Specialty Code), Functional Account Code (FAC) ,or National Stock Number (NSN), the personnel and equipment resources required for the package (AFCESA 1, 1993:F-4).

For Example, Prime BEEF (Base Engineer Emergency Force) is the general team designation for deploying Air Force civil engineering forces. There are actually two, recently restructured, Prime BEEF combat support packages, CS-1 and CS-2, ranging in size from 50 to 100 personnel, with specific training and experience requirements, with a similar range of accompanying supporting equipment (AFCESA 1991: C-1). Further incrementation of civil engineering functions including fire protection, staff augmentation, heavy equipment, airfield lighting, and generator plant operations are categorized into their own UTCs (AFCESA 1991: C-1). WRM resources are also categorized by UTCs incrementing equipment, expedient materials, and vehicles into pre-positioned packages of various sizes and capabilities. Further classification of UTCs includes Independent Core

and Dependent Core packages designed for independent operations or marriage with an independent core UTC. Additionally, there are Round-Out UTCs designed to meet additional installation requirements unmet by core UTCs and also Destination-Unique UTCs which are designed for specific locations. Lastly, CONUS and established overseas operating bases maintain their own packages of personnel and equipment should they be designated by the TPFDL to bring their resources with them.

Finally, as some contingency situations are slow or unlikely to evolve, some pre-deployment initiatives and projects can be completed lightening the workload befores forces deploy to forward installations. In many cases major commands and numbered air forces will use BSPs as a means of generating peacetime project requirements and attempt to eliminate tasks before contingency situations arise.

The purpose here is not to provide a detailed explanation of planning procedures, indeed the actual standards vary slightly with the theater of operations, but to characterize the pre-deployment phase of contingency operations. If one is to propose a basis for a hazardous materials and waste management system, it must be developed in accordance with the planning and organizational conventions and protocols used during this phase.

Deployment

In the ideal situation initial developments occur in the exact manner as plans anticipate and specific TPFDLs are employed to muster forces and equipment. In some cases events happen over a period of time and some warning time is given to troops that potentially may be deployed. This is used to get personal affairs and gear in order along with ensuring UTCs are filled exactly as called for by specific listings. This time period

can also be used to *augment* deployment packages as may be deemed helpful to the particular deployment location. Such augmentation can only go so far if air transport is to be employed. UTCs detail specific pallets on which equipment is to be carried onboard aircraft. Weight and balance constraints are a flight safety issue. Most experienced personnel have encountered strict, unhumorable aircraft loadmasters and are aware of the tight limits placed on cargo. In the case of sea, rail, or land transport more leeway is available.

In other cases, little warning is given to deploying forces or established plans are not in place for unanticipated events, and leadership must put together deployment packages as quickly possible. In preparation for such cases, assets belonging to a particular UTC must be stored, secured, inspected, and re-inspected properly over time to ensure pallets will not be *frustrated* during the aircraft loading process and that deploying packages are complete and ready for immediate use when they arrive in the field. Once again, experienced personnel have seen hectic, last minute efforts to reconstitute UTCs because materials have decayed beyond functional use or even been *borrowed* for use between deployments or exercises.

All combat support units are governed by the Joint Chiefs of Staff (JCS) Memorandum of Procedure (MOP) 189, which establishes requirements for regular readiness capability reporting through the Status of Resources and Training System (SORTS) to the JCS. SORTS defines a unit's capability to undertake its wartime mission as ranging from C-1, having met all resource training requirements, to C-5, in which a unit is unprepared to accomplish wartime taskings (JCS 189, 1985:1).

Except in extreme cases, where it is of strategic importance to move aircraft into operational theaters immediately and crews are expected to beddown as best possible with what is available on-site, it is usually Prime BEEF teams which arrive first to prepare the installation for other incoming forces which will be arriving very rapidly. Upon arriving and finishing initial off-loading processes, deploying commanders are faced with prioritized lists of tasks to be completed to *stand up* the installation for operations. Given the range of possible deployment sites from austere to main operating bases, the range of required tasks also covers a broad spectrum, There are however basic prioritized tasks which if not already fulfilled will have to be accomplished.

Of first priority is the airfield which supports the Air Force's only reason for being in theater. In decreasing priority, other actions which must be taken include the establishment of a potable water source and other sanitary facilities; construction and initial hardening of direct operational support facilities including ammo and fuel storage locations; construction of maintenance, operations, and supply facilities; construction of indirect operational support facilities including roads and utilities; and lastly the construction of special and general housing (SOCES 1, 1993:G-4).

Some of the main types of expedient assets found in WRM packages which will be used extensively in most deployment theaters are the Harvest Eagle and Harvest Bare sets. Harvest Eagle is an air transportable package of housekeeping equipment, spare parts and supplies required for support of general purpose forces under bare base conditions. Each kit provides softwall (tents) housekeeping support for 1100 persons. Harvest Eagle is not intended to be an all inclusive package for sustained operations, but can be used in a bare base setting until augmented by Harvest Bare (AFCESA 1, 1993: 4-4).

Harvest Bare, also air transportable, is a package of hardwall shelters designed to provide a broad base of logistics support for sustained operations at bare bases for 4500 personnel (3 to 5 flying squadrons). In recent years modifications and enhancement have been made to the basic Harvest Bare package, tailoring it for the Southwest Asia theater where a greater number of bare base operations is expected (AFCESA 1, 1993: 4-4).

Once again, this description of the general deployment scenarios is given in order to provide for the background into which a contingency hazardous materials and waste management system must be integrated.

Sustainment

The sustainment phase represents the time when all operational functions and procedures are being implemented on a recurring basis and personnel are in semi-permanent housing. During this time period support forces can turn their attention to improving operations, more permanently hardening facilities, and establishing recurring services for the base's organizations and personnel. Expedient, mobile systems can be replaced with longer term, more permanent systems. Harvest Eagle assets can be enhanced or replaced with Harvest Bare assets or even hardened, permanent construction. Finally, operating methods and procedures which may initially require a reduced degree of safety for the sake of expediency, can be replaced with methods and procedures closer to those used at home and thus reduce the potential for adverse mission impacts.

Another recurring function which will take place during the sustainment phase is the identification of supply requirements and the recurring transportation and delivery of such materials. Hazardous materials supply procedures vary from site to site. In some

cases delivery is made to large supply yards. Petroleum, Oils, and Lubricants (POL) delivery is made directly to holding tanks. Solvents, plating chemicals, and hydraulic fluids are delivered and stored on site. Standardized re-supply procedures are not in place across the Air Force and often are developed as convenience dictates during the deployment phase.

The same is true for the processing of hazardous wastes. Often wastes are stored on site until practical volume constraints necessitate a central storage location. Central storage sites are not always called for in BSPs, and minimal siting forethought is employed. Contracting for ultimate disposal via the Defense Reutilization and Marketing Office (DRMO) also is non-standardized. As bare bases usually do not have such support organizations, they must wait for support from a main operating base. Once again, volume constraints have to be exceeded before action may be taken. In the Central Command theater of operation DRMO is not available, so Army contracting personnel are responsible for the contracting of ultimate disposal.

Re-deployment

In the case of force withdrawal or even deployment to new locations, some assets which were put in place in previous phases will have to be disassembled. In some cases, host nation forces may desire some assets to be left in place, but usually some return to a prior state will be desired. Large stockpiles of supplies, tent cities, and vehicle lots will be expected to be removed. Theater commands cite host nations asking for assistance in cleaning up the messes left behind by deploying forces. As seen in the Mogadishu Airport case, inadequate re-deployment measures can lead to slowdowns in force withdrawals.

Assets are expected to decay, breakdown, be used up, or otherwise depreciate during the sustainment phase. Some care is necessary in trying to put deployment packages together to account for all assets as best possible and to ensure equipment, that no longer meets standards is repaired or at least documented. Equipment that remains somewhat mobile due to good care and maintenance or is readily re-deployed will be a much greater asset to leadership when repositioning within theater is required. In re-deployments it is difficult to expect well defined plans for withdrawal or repositioning using the guidance of TPFDLs or specific UTCs, therefore personnel and equipment flexibility is an essential attribute.

As with the other phases, this general description is provided to clarify the environment in which a management system will have to exist. As will be discussed in Chapter Three, the establishment of a rigorous methodology for development of such a system requires one to characterize the environment and systems in order to identify constraints which will have to be satisfied by the system.

Applicable Laws and Regulations

A variety of strict laws and detailed regulations apply to the management of hazardous materials and wastes on Air Force bases at home. As one moves to US military installations overseas applicability becomes slightly less clear but is still defined through additional sources of regulation. Progressing onto host nation bases, bare bases, and contingency environments including scenarios with the threat of imminent hostilities, the applicability of laws becomes very unclear. This portion of review will briefly cite some of the laws and Air Force policies which apply at home, how they generally apply and are

further clarified overseas, and what guidance exists in the case of more extreme threat conditions.

In the US

The following federal laws, executive orders, and Air Force policies relate to hazardous materials and wastes. They apply to installations in the 50 states and all US territories. A very brief description of how each law relates is given.

National Environmental Policy Act (NEPA) - This legislation requires federal agencies to consider environmental effects in its decision making process. Obviously, hazardous materials and waste management planning and implementation can have considerable environmental impact. An environmental impact assessment process is detailed in this law (Army, 1995: A-4).

Resource Conservation and Recovery Act (RCRA) - This legislation establishes the nation's framework for managing hazardous waste. It established temporary storage limits, accumulation site specifications, and treatment and disposal permit requirements. RCRA specifics will be addressed in the materials section of this review. RCRA also establishes the "joint and several" liability of all those involved with the cradle-to-grave management of hazardous waste, making generators responsible for ensuring that organizations which dispose of the generator's waste do so properly (Army, 1995: A-4).

Occupational Safety and Health Act (OSHA) - This act establishes the Occupational Safety and Health Agency making it responsible for the development and enforcement of safety regulations for personnel working around hazardous materials. It is the OSHA Hazardous Communication Standards Program (HCS or HAZCOM) which details personnel training requirements for working with hazardous materials. It is also requires Material Safety Data Sheets (MSDS's) to be kept in facilities housing hazardous materials. HCS specifics will be addressed in the materials section of this review (Army, 1995: A-4).

Clean Water Act (CWA) - This legislation, establishing sewer and stormwater discharge standards, designates requirements for reporting hazardous substance spills into waterways (Army, 1995: A-4).

Comprehensive Environmental Response Compensation and Liability Act (CERCLA)- This legislation, establishes liability for individuals and organizations responsible for release of hazardous substances into the environment and also establishes the *Superfund* to provide for the cleanup of hazardous waste sites. The Department of Defense counterpart is the Installation Restoration Program (Army, 1995: A-4).

Emergency Planning and Community Right-to-Know Act (EPCRA) - This legislation requires facilities to report inventories of hazardous materials to local emergency planning committees (LECP's), to provide immediate notification of

hazardous substance releases, and to submit annual report of hazardous substance releases (Army, 1995: A-4).

Federal Facilities Compliance Act - This legislation officially required federal facilities to comply with RCRA and strengthens the ability of regulatory agencies to impose fines and administrative action on federal agencies (Army, 1995: A-4).

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) - This law details and requires the proper management, use, storage, and disposal of pesticides(Army, 1995: A-4).

Toxic Substances Control Act (TSCA) - This law establishes requirements for the testing and restriction of toxic substances. The main focus TSCA is the regulation, limitation, and elimination of chloroflourocarbons, polychlorinatedbiphenyls, asbestos, dioxins, and other toxics (Army, 1995: A-4).

Uniform Code of Military Justice(UCMJ) - Military members who break environmental regulations or laws can be court-martialed under various sections of the UCMJ including dereliction of duty, failure to obey an order, and destruction of government property. Non-judicial punishment can also be used in response to regulatory violations (Army, 1995: A-4).

Executive Order 12088 - This order requires federal facilities to meet all federal, state, and local environmental regulation and establishes reporting processes for non-compliance findings (Army, 1995: A-4).

Executive Order 12580 - This order in response to CERCLA partially amended Executive Order 12088 and required the establishment of National Contingency Plans to provide for national and regional response teams composed of various federal agencies (Army, 1995: A-4).

Executive Order 12856 - This order called for the Federal Government to lead by example in source reduction and calls for a 50 percent reduction in toxic releases by 1999 (Army, 1995: A-4).

DOT Regulations - The Department of Transportation maintains and enforces a variety of regulations relating to the proper classification and naming of hazardous substances, general restrictions on such substances, proper packaging and labeling of containers, and manifesting of hazardous substances for shipment. DOT regulations do not apply to the local transportation of substances within an installation (Army, 1995: A-4).

Air Force Instruction 10-204 - This instruction requires that exercises and deployments be evaluated through the environmental impact assessment process.

Air Force Instructions10-210 and 10-211 - This instruction encourages the implementation of environmental quality principles and assessment techniques throughout the Air Force.

Air Force Instruction 10-403 - This instruction designates Civil Engineering as having the responsibility of ensuring that deployments meet environmental standards.

Air Force Instruction 32-7001 - This instruction details the Air Force's environmental budgeting efforts regarding compliance, cleanup, conservation and pollution prevention.

Air Force Instruction 32-7002 - This instruction details the Air Forces Environmental Information Management System, establishing base environmental protection committees (EPC's), and establishes some functions of environmental engineering flights. The instruction also calls for the reporting of compliance violations, cleanup and pollution progress reports, and the management of conservation and other environmental initiatives.

Air Force Instruction 48-119 - This instruction calls for the proper disposal of medical wastes.

Air Force Instruction 32-7042 - This instruction calls for the proper management and disposal of solid and hazardous wastes.

Air Force Instruction 32-7045 - This instruction establishes the Environmental Compliance and Assessment Program (ECAMP), a method of inspecting Air Force bases to ensure all federal, state, and local regulations are complied with, including those relating to hazardous material and waste management .

Air Force Instruction 32-7047 - This instruction details the reporting of regulatory findings of non-compliance.

Air Force Instruction 32-7060 - This instruction details the Air Force environmental impact analysis process.

Air Force Instruction 32-7080 - This instruction establishes the Air Force's pollution prevention program, encouraging source reduction and elimination efforts.

Air Force Installations Overseas

Most of the laws and regulations cited above do not refer to US installations overseas and it is unclear how they may apply. Those that specifically deal with overseas bases and relate to hazardous materials and waste management are detailed below along with a brief description of the relationship;

Executive Order 12114 - This order establishes the requirement for a basic environmental impact assessment process to take place in support of federal actions abroad. The Department of State is designated as the coordinator between federal agencies and foreign governments. The order's objective is to increase cooperation with foreign environmental regulatory agencies (Army, 1995: A-4).

Air Force Instruction 10-204 - This instruction requires that exercises and deployments be evaluated through the environmental impact assessment process.

Air Force Instruction 10-210 and 10-211 - This instruction encourages the implementation of environmental quality principles and assessment techniques throughout the Air Force.

Air Force Instruction 10-403 - This instruction designates Civil Engineering as having the responsibility of ensuring that deployments meet environmental standards.

Air Force Instruction 32-7045 - PACAF, CENTAF, and USAFE use the ECAMP process at overseas installations to ensure that environmental standards are being complied with.

Overseas Environmental Baseline Guidance Document (OEBGD) - These documents are drawn up by theater major commands and represent environmental

requirements overseas. They are divided into protocols, ranging in number form seven to twelve, based on federal laws and regulations at home. Two protocols, addressing hazardous materials handling and hazardous waste management, were found in both researched OEBGD's. Both Pacific Air Forces (PACAF) and Central Air Forces (CENTAF) use these documents in conducting ECAMP's at all main and collocated operating bases (PACAF, 1994) (CENTAF, 1995).

Final Governing Standards (FGS) - These standards represent the host nation's environmental laws and regulation integrated with US laws, regulations, policies. In some countries, primarily European nations, where environmental regulations are stricter than at home, installations often must comply with the more stringent standard.

Status of Forces Agreements (SOFA) - These agreements with host nations address jurisdictional issues regarding the actions, arrest, detainment, legal trying, and possible imprisonment of personnel stationed overseas. Personnel stationed or deployed overseas who violate host nation environmental laws can be turned over to the host nation's legal system.

Uniform Code of Military Justice (UCMJ) - Military members who break environmental regulations or laws overseas can be court-martialed under various sections of the UCMJ including dereliction of duty, failure to obey an order, and destruction of government property. Non-judicial punishment can also be used in response to regulatory violations.

Bare Base and Increased Threat Environments

Bare bases may not possess the facilities or infrastructure to properly comply with the OEBGD or FGS and deploying forces may require significant time to accomplish higher priority tasks before they can address such shortfalls. No precedent could be found for the ECAMP process being applied to bare bases in the short term after initial deployment. Air Force Instructions 204, 210, and 211 still stress the application of environmental quality principle's and the assessment of deployment impacts.

Executive Order 12114, which addresses the environmental impact analysis process overseas, specifically states that

> "...situations involving immediate national security concerns or foreign governments that require prompt action preclude full compliance with NEPA. ...An exemption to the environmental impact assessment process is authorized in the course of armed conflict, and the exemption applies as long as the armed conflict continues" (Army, 1995: A-4).

Obviously, regular exercises and recurring deployments should be part of the regular environmental impact assessment process. The responsibility of accomplishing the assessment is generally assumed by theater commands. In the case of rapid, unplanned deployments and specific actions while deployed, it seems that a brief memorandum will suffice. In the case of armed conflict or imminent hostilities actions of much higher priority and immediate importance clearly take precedence.

The UCMJ and SOFAs still apply regardless of threat conditions and deployment conditions, and personnel can still be court-martialed or turned over to host nation legal systems for illegal actions. Some mention should be made of wartime rules of conduct as established by international conventions to the which the US is signatory. Article 55 of

the Hague Convention requires belligerents to safeguard the real property of hostile states and to administer such property in accordance with the rules of conflict. Additionally, Article 51 of the Geneva Convention forbids any destruction of real property unless it is absolutely necessary for the conduct of military operations (Reisman, 1994: 69). Finally, the 1977 Convention on the Prohibition of Military or Any Other Use of Environmental Modification states that actions which cause severe damage,

> "involving serious or significant disruption or harm to human life, natural, or economic resources or assets...lasting for a period of months, or approximately a season...encompassing an area on the scale of several hundred square kilometers...are prohibited" (Reisman 1994: 73)

These conventions are obviously established in response to specific past actions enemies have taken on one another. It is unclear if these agreements can be applied to actions which take place within allied countries by another allied nation; however, callous, large scale dumping of some hazardous materials wastes can lead to substantial environmental damage and it is conceivable that post hostility legal action could be undertaken.

The purpose of this section was to review the various laws, regulations, and policies which apply in the contingency environment in order to provide a background for establishing the objectives and constraints of contingency hazardous material and waste management system.

General Handling Precautions and Considerations

The range of types and subtypes of hazardous chemicals now being required for the support of Air Forces in the field is extremely extensive, including fuels, lubricants, coolants, sealants, hydraulic and breaking fluids, fire suppressants, pesticides,

disinfectants, adhesives, paints, medical supplies, film developers, electroplating solvents, cleaners and degreasers, metal finishers, batteries, laboratory testing materials, and others (Brown, 1991: 4-5). The spectrum of process residues and wastes corresponding to these substances is also quite broad. A detailed analysis of the specific hazards, safety precautions, and host of regulations associated with each is beyond the scope of this research. There are, however, generalized good storage and handling practices and considerations recommended in the literature, which if implemented on deployments could further reduce the risk of releases and harmful exposure and provide for the general safe handling, storage, and processing of hazardous substances. Phifer (1990:72) cites the following eight main factors involved in the proper storage and handling of hazardous waste in the US:

1. Compatibility of Materials
2. Packaging
3. Regulatory Compliance
4. Segregation of Wastes
5. Ventilation
6. Climate/environment
7. Space
8. Economics

These factors will be used in this portion of review as a framework to briefly detail general handling considerations and methods. Regulatory compliance for compliance sake may not be of much concern in contingency situations, but there are two regulatory standards, the OSHA Hazardous Communication Standard and RCRA's hazardous waste processing

requirements, which are based on established safety concerns, and therefore partial adherence to the underlying principles may be of some value on deployments.

Compatibility

Phifer cites several examples of materials which if brought into close contact yield poisonous gases, considerable amounts of heat, fire, corrosion or explosion. Phifer then categorizes these concerns regarding hazardous materials into compatibility with other materials and wastes, containers, nearby materials and equipment (Phifer, 1990: 73). Users must therefore take precautions in hazardous materials packaging and storage.

Packaging

DOT has established specifications regarding how to properly package specific hazardous materials and wastes. If possible, materials should remain in the original manufacturer's containers. Containers should be readily transportable, durable, protected from corrosion or wear, and not readily tipped, spilled or punctured. As will be discussed next in the reviews of regulatory mandates, proper labeling is essential for alerting personnel of proper cautions to be taken with the material (Phifer, 1990: 75).

Compliance with the OSHA Hazardous Communication Standard

HCS seeks to ensure that the hazards of all chemicals are identified and that this information along with corresponding protective measures, is provided to personnel who may be potentially exposed to the hazard (Waldo, 1993: 9). The mechanisms used by

HCS to accomplish this goal are Material Safety Data Sheets (MSDS's), warning labels, and established training programs.

HCS determines a chemical to be *hazardous* if it is either a physical or health hazard. A chemical is considered a physical hazard if there is scientific evidence that it meets specific standards classifying it as combustible liquid, compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable, or water-reactive. A health hazard is defined as any chemical for which at least one scientific study establishes statistical evidence of causing acute or chronic health effects in exposed employees (Lowry, 1985: 39). Once determined to be hazardous, the chemical's manufacturer is required to prepare an MSDS.

HCS mandates that manufacturers supply MSDSs to any customer's purchasing their product and that any user procure the appropriate MSDS from the manufacturer. The MSDS serves as the primary on-site source of information on the hazards associated with a chemical, corresponding protective measures, and emergency guidance. Specifically, MSDSs are required to contain in English the following twelve pieces of information about the material:

1) the specific chemical identity and its components
2) its physical and chemical characteristics
3) physical hazards
4) health hazards
5) primary routes of exposure
6) regulatory exposure limits,

7) carcinogenicity

8) applicable safety precautions for safe handling

9) applicable control measures

10) emergency and first aid procedures

11) date of MSDS preparation and latest revision

12) the name, address, and telephone number of parties who can provide additional information on the chemical and emergency procedures.

MSDSs must be readily accessible to employees working in close proximity to the corresponding chemicals. This is usually accomplished via notebooks kept in the same facilities housing the chemical. Computerized storage of MSDSs is permissible if access is available to all employees (Brown, 1991:19).

HCS also requires specific labeling requirements for chemical containers. Labels must contain the identity of the chemical and hazards most significant to employees under foreseeable conditions of exposure. It is not required that every hazard comprehensively listed on the MSDS be on the label, however carcinogenic properties are very specifically required by HCS to be displayed on the container. If it is foreseeable that the chemical container may leave the facility housing the corresponding MSDS, then the label must contain name, address, and contact information of responsible parties having further information about the chemical. It is the responsibility of the manufacturer to prepare adequate labeling for containers of their product and make them available to customers, however the user is also responsible for procuring the proper label, ensuring it displays proper information, and is displayed on the container (Lowry, 1985: 59).

HCS also requires minimum training for employees working with or in close proximity to hazardous chemicals. Specifically, the following four topics must be covered with the employee: 1) how to detect releases, 2) the physical and health hazards of the chemicals in the workplace, 3) protective measures, emergency procedures, and the use of protective equipment, and 4) and an explanation of the employer's hazard communication program including explanation of the labeling system and how employees can obtain access to the MSDSs (Brown, 1991: 28).

RCRA Requirements

Most processes using hazardous materials do not completely *use up* the material; consequently they typically produce hazardous wastes. In the US, the Environmental Protection Agency (EPA) regulates cradle-to-grave hazardous waste procedures under Subtitle C of RCRA and the subsequent set of Hazardous and Solid Waste Amendments of 1984. The purpose here is to briefly review how RCRA defines hazardous waste and regulates the generation and temporary storage of such waste.

RCRA considers a waste hazardous when it exhibits one or more of the four specifically defined characteristics of hazardous waste, ignitability, corrosivity, reactivity, and toxicity. Furthermore, the EPA may *list* any waste which is presumed to be hazardous. Additionally, mixtures of hazardous wastes with non-hazardous products and wastes derived from hazardous wastes are considered hazardous. Materials become hazardous wastes generally "when their intended use has ceased and they begin to be accumulated or stored for disposal, reuse, or reclamation." (Neitzel, 1992: 15).

While RCRA details specific hazardous waste production rates for EPA permitting and generator size classification, the main concern of this review are the standards for on site and intermediate storage of generated wastes at accumulation points. A generator may accumulate up to 55 gallons of hazardous waste or 1 quart of acutely hazardous on site, referred to as a *satellite accumulation area*, if containers are managed properly, labeled properly with the words *Hazardous Waste* and with the date of first accumulation, and maintained in good condition. If the 55-gallon or 1-quart maximums are exceeded for more than 90 days the generator becomes the operator of a storage facility, subject to much more stringent regulation (Wagner, 1990: Ch.3).

After the volume limit is reached at a satellite accumulation area, the generator has three days to move containers to a hazardous waste accumulation point (HWAP) where the 90-day time limit starts. Operators of HWAP facilities are required to regularly inspect the facility for malfunctions, deterioration, operator errors, and discharges which may lead to release or threat to human to health. Each facility must have a contingency plan designed to minimize hazards in the case of release, fire explosion, or emergency. Hazardous waste accumulation points are required to have specific equipment on site, including grounding devices, protective equipment, an alarm system, a device to contact emergency personnel, portable fire extinguishers, fire-control equipment, and access to fire-fighting water supplies (Wagner 1989: Ch4).

RCRA also details requirements for the transferring of hazardous wastes. Air Force bases in the states, through DRMO, prepare wastes for contracted shipment from accumulation points to disposal facilities using the DOT and EPA Uniform Hazardous Waste Manifest (UHWM). The one-page form with multiple carbon copies is designed so

that hazardous wastes shipments may be recorded and tracked from point of generation to disposal facility by generator, shipper(s), receiver(s), Federal, and State Agencies (Wagner, 1989:Ch4).

OSHA inspectors enforcing HCS will be hard to find in contingency environments. However, the underlying principles of the HCS, understanding what makes a material hazardous, making information available to personnel through MSDS's, increasing awareness through labeling, and training handlers to understand hazards, precautionary methods, and emergency procedures, can be used in the development of management methods for deployments. Similarly, the EPA will not be found scouting bare bases in times of increased tensions, but the concepts of not allowing waste to excessively accumulate over long periods in the workplace, limiting the time it stays on the installation in hazardous waste accumulation points, and properly designing and equipping those points are motivated by their risk reduction attributes and should also be considered in the design process. Deployed personnel are used to the *55-gallon, 1-quart*, and *90-day* constraints placed upon them at home, and these may be readily applied as general guidance in the field.

Segregation of Wastes

Just as compatibility concerns should be considered in handling of hazardous materials, one must also take care that accumulated wastes are segregated according to the processes which generated them. Segregation reduces the potential for compatibility problems and also prevents mislabeling and mis-tracking of such substances which can lead to adverse consequences (Phifer, 1990: 76).

Ventilation

Hazardous materials and waste storage locations must not be tight, constricted facilities preventing the free flow of air and allowing for the build up of poisonous or explosive fumes. Ventilation is a must. Also, handlers should be equipped with appropriate respiratory equipment (Phifer, 1990:78).

Climate/Environment

One must consider the outside environment when managing hazardous substances. Hot climates and sunlight exposure can lead to increased pressure and swelling of containers, while moisture in both hot and cold conditions can cause deterioration. Storage locations should be away from water sources and food stores because rainwater and flooding can cause containment berms to be washed over potentially carrying leaking substances away and repositioning containers (Phifer, 1990: 79).

Space

Adequate space for access to containers is a must. Inadequate spacing can lead to vehicles and personnel bumping, puncturing, or tipping containers. Pallet and shelving systems can relieve some of these stresses and improve container mobility (Phifer, 1990: 80).

Economics

As usual, funding and resource constraints require one to carefully plan expenditures. Funding of better storage facilities, materials, assets and methods may be viewed as investments that may eventually pay for themselves or extensive spending that further reduces risks that were already low. Manpower constraints also apply. Investing in additional personnel and training may or may not be necessary for a given situation (Phifer,1990:81).

Phifer's list of factors involved in the management of hazardous materials and wastes, augmented with an understanding of the underlying principles supporting the OSHA Hazardous Communication Program and the hazardous waste management requirements of RCRA, can be used as a basis for designing a management system for the contingency environment. These considerations, however, are limited by the assets with which they are supported. The equipment and technological resources which can aid in the handling and processing of hazardous materials and wastes are reviewed in the next section.

Equipment, Material, and Technological Resources

As with other modern programs and methods used on deployments, hard assets, equipment, and technological resources will doubtless represent a primary component of a any hazardous materials and waste management system. The growth of environmental regulations and enforcement has spurred considerable innovation and ingenuity in the arena, and new products are being employed in both the public and private sectors. In many cases these products facilitate the management of hazardous substances. In other

cases, traditional assets and methods are proving to continue to be the best solution to such problems. This section will attempt to list some of the many hard assets, equipment, and technological resources both old and new that may employed in the field and note items of particular interest. Such assets may be grouped according to which aspects of hazardous substance handling and processing they address. These categories include information systems, packaging and containment, storage and handling, safety equipment, release detection, and spill containment and response.

Information systems

As previously discussed, the OSHA HCS specifies how information relating to a user's hazardous materials is to be managed and distributed. Information management is crucial not only to regulatory compliance but in communicating hazards, precautions, and emergency procedures. RCRA rules require proper dating, tracking, and manifesting of hazardous wastes. Traditionally notebooks, dividers, stacks of blank forms and filing cabinets have filled this need. Given the ease and capacity with which modern computers manage information and the paperwork required for proper hazardous materials management, it is only logical to assume that software producers would begin to address the issue.

FastSearch Corp. is one of many software companies marketing CD-ROM packages advertised as having "complete" EPA, DOT, and OSHA regulations with recurring updates available (Compliance, 1995:33). Labelmaster Co. is advertising its Hazardous Materials Information System which claims to allow many placards and labels to be produced on site via computer print out and then attached to containers via several

methods (Compliance, 1995: 31). PEAK Software Products has released MSDS-Maker 1.0, advertised as "an expert system" which "creates MSDS documents for EPA, DOT, and OSHA listed substances by extracting information from a raw material database and transcribing the most appropriate information (Compliance, 1995: 28). Other companies advertising similar products include Safety Software Inc., J.J. Keller and Associates, and PC Compliance Co. (Compliance, 1995). Costs for such products range from a hundred to a few thousand dollars.

Packaging and Containment

The traditional fifty-five gallon, three-ribbed, steel drum is the standby for hazardous substance containment. Drums now are made of a variety of materials with different coatings, capping and bunging devices, and other innovations. Smaller gerry cans, tanks, and other containers are just as diverse. Flammable storage lockers have also been around for many years and now can be found with a similar variety of sizes, materials, locking mechanisms, and other safety innovations. Larger secondary containment systems, essentially large lockers ranging in capacity from 1 to 120 drums, begin to blur the line between containment and storage. Overpacks designed for damaged drums and other bulk containers are made of polyethylene blends impervious to most chemicals, solvents, and corrosives. Pressurized steel and aluminum canisters of a variety are the traditional means of compressed gas storage.

Several companies including Akro-Mills Inc., Buckhorn Inc., and SSI Schaefer Inc. are currently selling collapsible container systems made of reinforced, mylar treated or lined cardboard boxes which are advertised as being able to handle many hazardous

liquids. The light weight and low volume of the empty, collapsible containers when compared to steel drums makes the product attractive. DOT approval seems to be questionable, according to competitors (Material, 1995:11)

Storage and Handling

The traditional standards in this category include shelving, pallets, electric and roller conveyors, forklifts, hand trucks, pallet trucks, storage sheds and lockers, drum lifters, safety-lock belts and chains, fencing, magnetic lifts, grounding systems, ventilation systems, and a variety of drum dispensing devices. Of some interest is Shaefer Systems International Inc. which is marketing essentially an outdoor locker and shelving set as its *Mobile HazMat Pharmacy* to the Navy (Schaefer, 1996:1).

Safety Equipment

The standards in this category include eyewashes, showers, first-aid kits, fire extinguishers, and non-slip flooring. Personal protective equipment ranges from eyeglasses, hard hats, respirators and breathing equipment, lifting belts, gloves and boots of various materials, to complete rubberized or fireproof suits (Lab Safety Supply, 1994: 160).

Detection

The staples of this category include fire alarms, heat and flash detectors, video cameras, audial detection systems, detection badges, and a variety of gas and vapor

sensors and monitors, pH testers, liquid and soil sampling systems, dosimeters, and diffusion tubes, (Lab Safety Supply, 1994: 286).

Spill Containment and Response

A large variety of spill kits of various sizes are produced by several companies. Components include sorbent booms, pads, and blankets, and granular or clay sorbents, spark proof shovels and scoops, a variety of personal protective equipment and various container systems. Containment systems range form the traditional earthen, concrete, or plastic secondary containment dikes and berms to spill skids and oversized spill containers for leaking drums (Fibrex, 1995: 1).

This listing of equipment and supplies was undertaken to briefly describe the physical assets which may be employed, in conjunction with other considerations described in previous sections, in a hazardous materials and waste management system for contingency deployments.

In Review

In order to develop objectives and define constraints for the purpose of developing a management system, one must first provide some description of the general background into which such a system will be employed. Using an extensive review of contemporary literature and institutional experience five goals were achieved. The intersection of environmental thinking and discussion, past experiences, and command interest indicate the presence of a systemic problem in managing hazardous materials and wastes during contingency deployments. The conventions and materials used in and environment

surrounding contingency deployments was described in its four phases of pre-deployment, deployment, sustainment, and re-deployment. The variety of laws, regulation, and policies which apply to the management of hazardous materials and wastes at home and may apply abroad were briefly detailed. The specific materials common to Air Force deployments and the associated safety concerns were investigated. Finally, the broad variety of equipment, technological, and material resources available to aid in the management of hazardous materials and waste was reviewed.

This information can now be put to use in characterizing the basic problem at hand and defining the objectives and constraints of a management system. A methodology must now be employed which will synthesize the research of this chapter and provide for the design of such a system. The development of this methodology is accomplished in the next chapter.

Chapter III

Methodology

The Need for a Structured Design Methodology

Proposing any solution to a systemic set of problems is a rather simple and easy undertaking. Just throwing out a collection of ideas, however, is no guarantee of success and indeed may be recipe for failure when time comes for implementation. A structured design and development process is necessary in order to address all phases and subsets of a problem. In his book Design, Planning and Development Morphology, Benjamin Ostrofsky notes that

> "a structured design morphology, then places in an orderly fashion the sequence of decisions which should be adequately resolved in order to emerge with an effective set of plans for the needs which have been identified" (Ostrofsky, 1977:3).

Such a process ensures that the designer has methodically considered the various facets of a problem, before implementation occurs and the designed system is tried and tested in the real world. This chapter attempts to develop a methodology that will address all of the structural components of the problem of managing hazardous materials and wastes in deployed field conditions and, as a result, guide the development of a basis for a management system and maximize the probability of success upon implementation.

Design Morphology

A Brief Literature Review

Most of the works on design processes define a basic developmental morphology in initial chapters and then expound upon its components in subsequent sections. Morris Asimow is repeatedly referenced in other texts as the original "pioneer" in the outline of design methodologies (Ostrofsky, 1993: xviii). Asimow breaks down the basic design methodology into 6 basic components:

1. Needs Analysis
2. Problem Identification and Formulation
3. Generation of Alternatives
4. Feasibility Study
5. Optimization
6. Production and Marketing Plans

(Asimow, 1960:7). Ostrofsky stresses development of "evaluative screening criteria," as opposed to constraints, which will guide one to a grouping of "synthesized candidate systems" into a final system (Ostrofsky, 1977: Chs 9 and 10). Other works such as P.H. Roe's, The Discipline of Design expound upon the creative art of imagination and innovation in solving "non-routine" problems (Roe, 1967: Ch.4). On the other side of the spectrum is J. Christopher Jones, who in Design Methods: Seeds of Human Futures, recommends iterative, rigorous, quantitative, criteria weighting and ranking procedures for purposes of evaluation (Jones, 1980:Ch. 5).

Each of the cited works are primarily concerned with commercial product development, although Ostrofsky devotes a chapter to defining criteria for operational systems (Ostrofsky, 1977:Ch.13). The basic methodology to be used in this study integrates elements of each of these cited design morphologies, adapting them into one suited for the purpose of qualitatively developing a management system. The following design process components, adapted from the works of Asimow, Roe, and Ostrofsky are detailed below along with a brief explanation of how they will be applied to the problem at hand.

Needs Analysis

Asimow directly addresses the purpose of a needs analysis,

> "In whatever way the need has been perceived, its existence must be established with sufficient confidence to justify the commitment of the effort necessary to explore the feasibility of developing the means satisfying it" (Asimow, 1962: 18).

In this case, the need for a deployable hazardous material and waste management system was established in the Literature Review and further definition is not necessary.

Problem Characterization

Roe divides problem characterization into two main parts, the first being the problem statement about which it is said:

> "When the problem has been properly identified the designer will be able to determine whether subsequent actions bring him closer to the desired end state... Because of the importance of problem identification, it is imperative for the designer to prepare a statement which positively defines the problem." (Roe, 1967:176)

This goal was accomplished with the objective statement first given in the introduction to this thesis. The objective of this thesis is to develop a system so as to safely manage the life-cycle flow of hazardous materials and wastes during Air Force contingency deployments, that primarily will minimize potential adverse mission impacts, and secondarily minimize post-deployment impacts.

Further characterization of the general problem is still necessary. Roe requires "...an examination of the environments in which the solution will exist," in order that "every relevant factor of the use environment be under stood." The detailing of the contingency environment in the literature review partially accomplishes this objective, but further characterization is needed in order to rigorously detail the differences between the peacetime CONUS base environment and the forward deployed field environment. This will be accomplished in Chapter 4. The methods and assets also detailed in the literature review list the basic tools available for further design.

Generating Alternatives

The creative portion of the design process is in developing potential solutions to the design problem and is the most difficult to rigorously turn from art into science. Jones recommends using creative brainstorming to generate individual initiatives spurred and guided with a framework established by the problem characterization process (Jones, 1980: Ch.4). In the next chapter, this framework will be established from the preceding rigorous characterization of the problem. This framework will then guide the creative process of brainstorming and employing ideas already in place in other situations. The

product of this step of the design process will be a listing of individual alternatives for further evaluation.

Screening Criteria

Ostrofsky explains, "Criteria present the means by which the performance of a system may be evaluated" (Ostrofsky, 1977:80). In the next chapter, the description of the contingency environment will be used to establish a set of criteria for the four basic phases of the contingency environment: pre-deployment, deployment, sustainment, and re-deployment. These will then be used to determine the feasibility of each of the initiatives, screening out those that fail to meet the constraints. After considerable thought it was decided that these criteria should be of a qualitative nature. The abstract nature of the problem would frustrate attempts to quantitatively rank initiatives and weight criteria. Quantitative results would be subject to inquiries requiring qualitative answers and defenses, and numerics would lead to more questions and doubt than they would provide clarity and understanding.

Grouping

Ostrofsky states that a "step in the…process of arriving at an optimal system is the grouping of candidates into natural sets." The purpose of this step will be to bring the various uncoordinated initiatives into a holistic management system which can be used a basis for establishing specific procedures, equipment lists, planning requirements, and assessment guidelines in the future.

Implementation

This final step corresponds to commercial efforts to plan for production and marketing after the basic components and characteristics of a product have been established. The purpose here will be to recommend programmatic steps to develop and test system prototypes, train personnel, and coordinate system functions with traditional deployment operations.

Anticipated Results

While this morphology may seem simple and straightforward, it will provide a rigorous methodology for ensuring that all factors of the problem at hand are considered in the design process. As a result the system will have the maximum possible likelihood of providing an effective basis for a solution to the problem of managing hazardous materials and wastes during contingency deployments and succeeding if or when it is tried and tested in real world field conditions.

Chapter IV

Analysis and Development

Overview

The methodology presented in the previous chapter was used to guide the analysis presented here. As previously discussed, the needs analysis was conducted as a function of the literature review and the project's objective problem statement was stated in the introductory chapter. This analysis begins with a further characterization of the problem in order to determine precisely which factors distinguish the management of hazardous materials and wastes in the peacetime-established main operating base situation from the deployed contingency environment found in the field. The characterization is then used along with the four time phases of deployments, established in the literature review, as a framework for generating alternatives. The contingency environment description from the literature review is then used to develop a list of screening criteria, which will be applied to the generated initiatives. Initiatives which are not eliminated from consideration will then be grouped together into a basis for a management system. Finally, recommendations for implementation are provided in the next chapter.

Problem Characterization

Further characterization of the problem requires a comparison of contingency and non-contingency environments. This characterization essentially reduces to one of

comparing the flows of hazardous substances through an established operating base during peacetime to the flows seen on deployments.

The Non-Contingency Environment

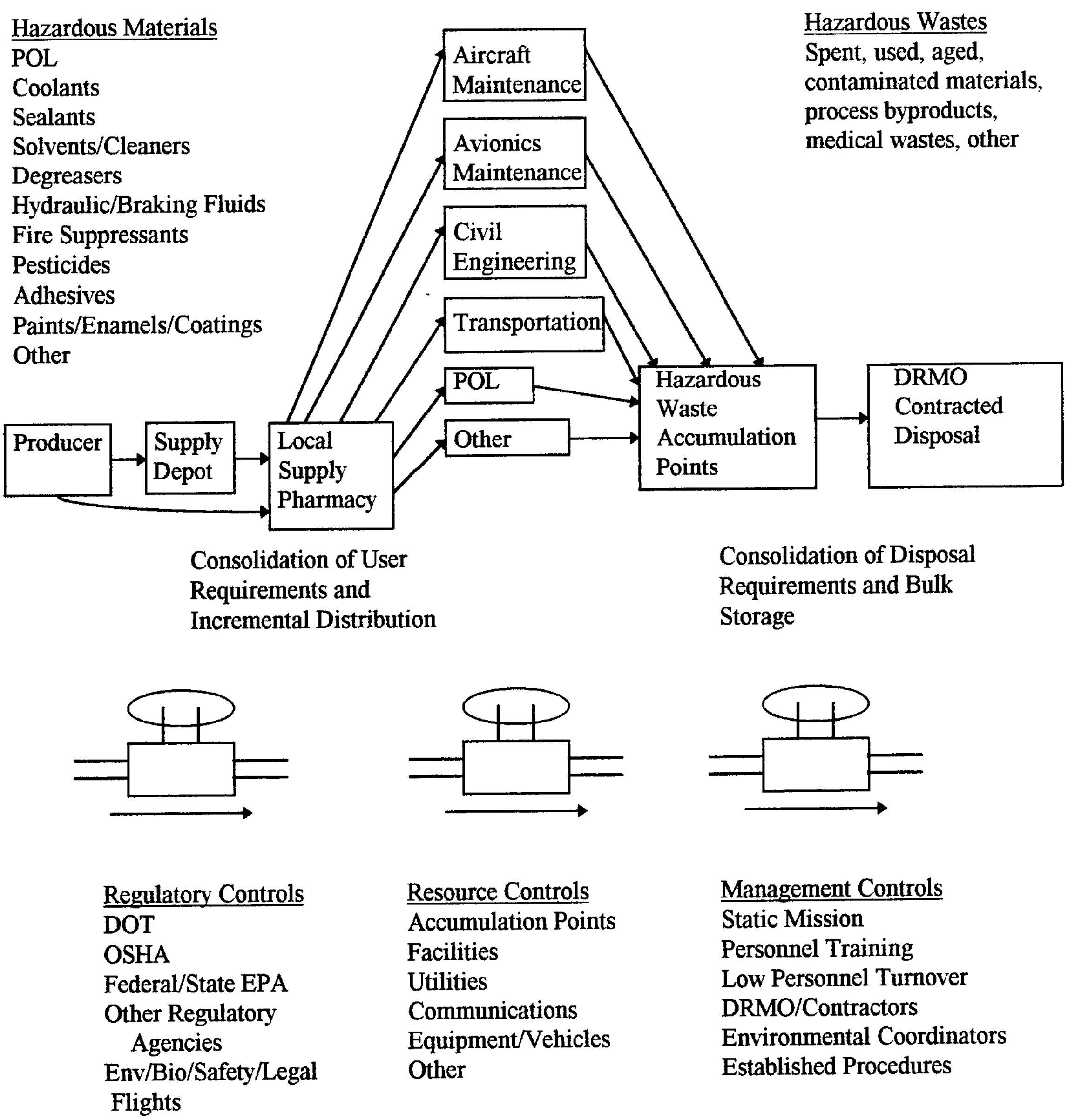
Figure 4-1 presents a generalized flow diagram for non-contingency situations. The various base operations order required hazardous materials through the base's supply system. Materials may be directly procured by the base, through the Government Services Administration (GSA) in which case economies of scale may require temporary storage at regional supply depots. Upon arriving at the installation, the materials are stored in a Hazardous Materials Pharmacy. The recently implemented hazardous materials pharmacy, as discussed previously, serves to ensure that incremental quantities are issued to users, preventing storage and shelf-life problems in the workplace. After accumulating appropriate quantities as determined by the RCRA limits, discussed in the literature review, wastes are transported to Hazardous Waste Accumulation Points (HWAP) on base, where they may be stored for up to 90 days. Finally, DRMO procures contracted pick-up and disposal and manifests the wastes for transport.

The flow of hazardous materials and waste is analogous to a *piping system* entering the base, *splitting* into a manifold of smaller flows through the various operations and maintenance processes on base and then *re-merging* through HWAP's for contracted disposal. This piping system prevents *leaks, spills, and over pressurization* at any point in the system through the use of *control valves* which keep flows within limits. The controls in place at the installation can be divided into three distinct categories.

Figure 4-1.

Peacetime Life Cycle Hazardous Material and Waste Flows

at Established Installations



Regulatory flow controls include various federal, state, and local regulatory agencies, who may inspect the base and assess fines and penalties if they find non-compliance. In addition, established bases have bioengineering, safety, and legal flights which also may inspect storage locations and the workplace for non-compliance. Periodic review and the threat of spot inspection and subsequent penalties help to ensure proper material and waste flows.

Established bases also control the process flow of hazardous substances with physical assets or *resource controls*. The existence of hazardous waste accumulation points, permanent facilities, electric power, running water, available vehicles, and available equipment allow installations to ensure proper handling of hazardous wastes and materials.

Finally, established bases have management assets in place which provide for the proper handling and processing of hazardous materials. So called *management controls*, include personnel training programs, management plans, and organizational environmental coordinators. Additionally, systemic conditions such as static mission environments provide for the development of established regular procedures, while low personnel turnover allows for collective knowledge of such procedures to grow and increase the likelihood that they are followed.

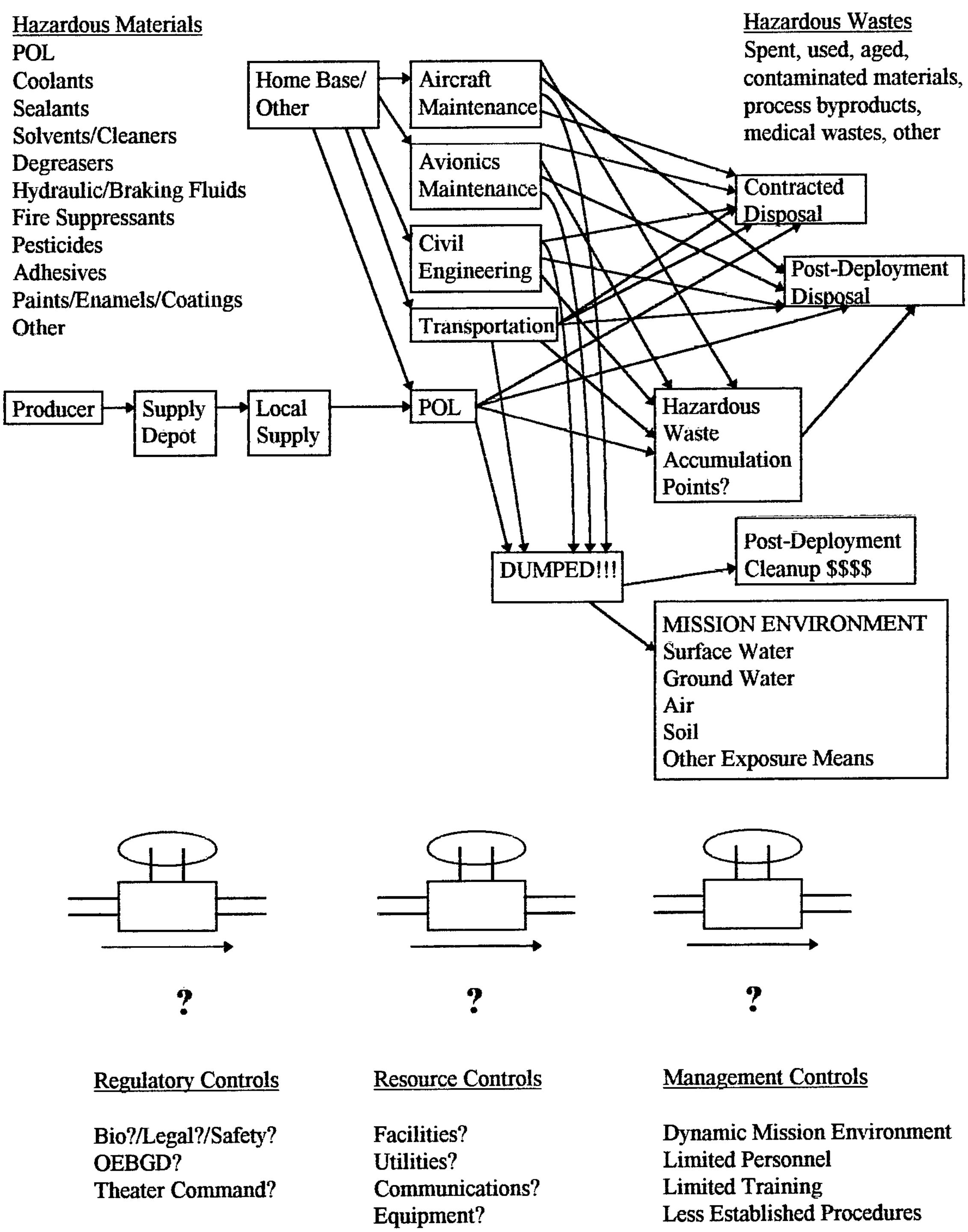
The Contingency Environment

In the field conditions are quite different, as shown in Figure 4-2. The busy nature of this figure itself provides an initial understanding of the problem. Supply lines are established on an *ad hoc* basis and, as a result, are numerous, varied, and inconsistent.

This occurs because the controls in place at established home bases are not as firmly incorporated into deployment operations.

Figure 4-2.

Contingency Life Cycle Hazardous Material and Waste Flows



Regulatory controls in particular are not expected to be in place to the degree that are at home. Regulatory agencies will not be conducting inspections in forward locations or increased threat conditions. The presence of bioengineering, safety, and legal support is questionable and priorities are expected to be elsewhere of such deployed organizations. In times of reduced threat conditions and stable operations, theater commands may inspect for OEBGD compliance, but such concerns are expected to be lower orders of business.

The existence of resources which contribute to flow control will vary from site to site. Bare bases may have no permanent facilities. Safety equipment, vehicles, and other technological resources will have to be deployed with forces and as a result may be in short supply. HWAP's and supply warehouses may not even exist, resulting in on-site or makeshift storage. Limited availability of communications, running water, and electric power may thwart the expedient construction of such facilities.

Management controls will be in short supply on deployments also. Familiar procedures and the designation of personnel as environmental coordinators will not be established, and new efforts are subject to regular change. Manpower and resources already in short supply will also have to be flexibly employed as they adapt to mission requirements. Facing a lack of guidance, knowledge, or even existence of established procurement, handling, processing, and disposal procedures, personnel will do what they must to accomplish their primary duties. Materials and wastes may be stored or disposed improperly, exposing forces and assets to potential hazards. As a result, the likelihood of adverse mission impact is increased.

This process of characterizing the problem by comparing hazardous substance flows in contingency environment to non-contingency situations has increased the

understanding of the problem at hand. Specifically, it has identified three main categories of differences between the two scenarios, explaining the inherent nature of the problem. These groupings of regulatory, resource, and management factors can now be used as a framework for generating initiatives which can substitute for the absence of the respective controls.

The Alternatives

A Framework for Generating Alternatives:

The three categories presented above represent the basic components of the hazardous substance management problem during contingencies. As established in the literature review, there are also four distinct phases of most deployments. By crossing this characterization of deployments with the categorization of control measures in matrix form (see Figure 4-3), one can establish a framework to guide the generation of alternatives addressing the subcomponents of the problem. As indicated in the matrix, the categories of alternatives are designated with two-letter abbreviations for purposes of presentation in the next section.

Additional clarification of flow control measures is also given to further aid in the generation of alternatives. Gray and Smeltzer define managerial functions as falling into one of four basic categories: planning, organizing, leading, and controlling (Gray, 16). The further delineation of resource measures comes from the categorization used in the literature review and the regulatory subcomponents are categorizations based on general requirements imposed by regulatory agencies.

Figure 4-3.

Matrix Guide for Generation of Alternatives

Deployment Phase: Control Measures	Pre- (P) Deployment	(D) Deployment	(S) Sustainment	Re- (R) Deployment
1.) Regulatory (inspections, penalties, reports)	P1	D1	S1	R1
2.) Resource (information systems, packaging/containment, storage/handling, safety, spill containment/ response)	P2	D2	S2	R2
3.) Management (plan, organize, lead, control)	P3	D3	S3	R3

It should be noted that the upcoming listing of alternatives is by no means exhaustive, but constitutes the universe of products of the author's ongoing brainstorming processes throughout the course of this project and general ideas expressed by others in discussing this research with the author. It should also be noted that a fundamental rule of the brainstorming process is that no ideas are passed over because of infeasibility, regardless of degree, in order to spur the generation of alternatives (Jones, 274). The process was limited, however, to Air Force actions only. The feasibility of the listed alternatives will be assessed later in the screening process. The reader should therefore

withhold judgment on each alternative until it is presented. Additionally, the measures are described in very general terms and will become more focused during the screening process. Lastly, the reader should note that the alternative of doing nothing and continuing with present practices is implied.

The Alternatives

The following is a listing of generated alternatives according to the categories designated in Figure 4-4; alternatives are further defined as necessary:

P1: Regulatory Measures taken in the Pre-Deployment Phase

P1 - 1. ORI and ECAMP functions: These inspections would be used to ensure existence and updating of contingency hazardous materials and waste management plans (as suggested by AFI 32-7006 and JCS 4-04) for deployment sites by wing planning organizations, personnel knowledge of such plans, and condition of deploying equipment cited by such plans as a function of recurring Operational Readiness Inspections (ORI's) and ECAMP.

P1 - 2. Theater Command Inspection: Theater Commands would conduct inspections to ensure existence and updating of contingency hazardous materials and waste management plans for deployment sites by wing planning organizations, personnel knowledge of such plans, and condition of deploying equipment cited by such plans as a function of recurring by governing theater commands. Reports sent to local wing's Major Command and Air Staff.

P1 - 3. Local Inspection: Wing personnel (Bioengineering, Safety, Environmental etc.) would conduct inspections for internal purposes.

P1 - 4 SORTS Reporting: Status of Readiness and Training (SORTS) reports would have an environmental readiness component added to their evaluation criteria.

D1: Regulatory Measures taken in the Deployment Phase

D1 - 1: Frustrating Deployment of Units: Theater Command could turn back units in the process of deploying who do not pass inspections.

D1 - 2: Inspection of Deploying Units: Theater Commands would conduct inspections of deploying units for purposes of establishing a knowledge base of potential problems. No frustrating of deployments would occur.

S1: Regulatory Measures taken in the Sustainment Phase

S1 - 1: Theater Command Inspection: Theater Commands would conduct recurring inspections of OEBGD compliance for purposes of establishing a knowledge base.

S1 -2: Local Inspection: Deployed bioengineering, safety, and environmental personnel would conduct recurring inspections for internal purposes.

R1: Regulatory Measures taken in the Re-Deployment Phase

R1 -1: Frustration of Unit Withdrawal: Theater Commands would conduct inspections with authority to frustrate withdrawal of units.

R1 -2: Local Inspection: Wing personnel would conduct inspections before and after re-deployment for internal purposes.

P2: Resource Measures taken in the Pre-Deployment Phase

P2 -1: Development of physical assets up to deployable HWAP's and HazMart's: Contract for the development of deployable hazardous substance management equipment in various degrees up to fully operational HWAP's and Hazardous Materials Pharmacies (HazMart's) composed of sheltering, safety equipment, detection equipment, secondary containment, handling equipment. communications, spill response, etc.

P2 -2: Assemble physical assets up to deployable HWAP's and HazMart's: Assemble deployable hazardous substance management equipment in various degrees up to fully operational HWAP's and HazMart's out of existing equipment resources and add to deployment packages and prepositioned assets.

P2 -3: Theater Command Programming for HWAP and HazMart construction: Theater Commands would program and construct permanent, equipped HWAPs and HazMarts at forward bases.

P2-4: Acquisition of Computerized Information Management Tools: Acquire and preposition software with safety regulation database, MSDS production capability, and label production capability for deployment packages and required hardware components.

P2-5: Traditional Information Management Systems: Preposition MSDS notebooks, stores of labels, and safety regulations in theater and require them to be a part of deployment packages which contain hazardous materials.

D2: Resource Measures in the Deployment Phase

D2-1: Construction of HWAP's and HazMart's: Require deploying forces to construct and equip such facilities in various degrees up to the point of fully operational, in compliance HWAP's and HazMart's.

S2: Resource Measures in the Sustainment Phase

S2-1: Construction of HWAP's and HazMart's: Require deployed forces to construct and procure equipment for such facilities in various degrees up to the point of fully operational, in compliance HWAP's and HazMart's.

S2-2: Develop and Establish Base Disposal Capability: Develop a safe deployable or on-site constructed disposal system for operation by deployed personnel.

R2: Resource Measures in the Re-Deployment Phase

R2-1: Provide Proper Packaging for Hazardous Substance Removal: In cases where a viable disposal contractor is not available, wastes may have to be removed by a variety of means. Properly labeled and manifested drums and overpacks will have to be handled, processed, and transported off site.

P3: Management Measures in the Pre-Deployment Phase

P3-1: Base Support Planning: Add construction of facilities of various degree up to fully operational HWAP's and HazMart's to the Base Support Plan. Program for construction before contingency arises. If deploying forces must accomplish construction establish priority in relation to other tasks. Site facilities with safety and risk minimization in mind.

P3-2: Develop a Hazardous Materials and Waste Management Plan: Predetermine how hazardous materials will arrive on base, be stored on base, processed in the workplace, where hazardous wastes will be stored on base, and how disposal will be accomplished. Plan should be addendum to Base Support Plan and distributed to deploying personnel (see appendix).

P3-3: Organize HCS and RCRA Training Sessions: Personnel should be acquainted with OSHA's Hazardous Communication Standards and basic RCRA procedures. They should understand the underlying safety concerns which if ignored could lead to adverse mission impacts. Ensure documentation of training is required on training reports and safety forms.

D3. Management Measures in the Deployment Phase

D3-1: Stress Awareness: Ensure personnel understand safety hazards and potential for mission impact as result of incomplete hazardous material and waste management resources.

D3-2: Select Personnel: Establish personnel responsible for manning the distribution of hazardous material and the collection, storage and disposal of hazardous waste.

D3-3: Institute Procedures: Establish procedures for hazardous material and waste management and ensure personnel are familiar with them. Ensure personnel are aware of existing materials and waste management plans and update such plans as necessary.

D3-4: Organize Construction Teams: Teams should be established to construct or complete construction to various degrees on HazMarts and HWAPs.

S3. Management Measures During Sustainment

(These measures are repeats of the deployment alternatives. As will be shown in the evaluation process later, the question is one of timing and degree of implementation.)

S3-1: Stress Awareness: Ensure personnel understand safety hazards and potential for mission impact as result of incomplete hazardous material and waste management resources.

S3-2: Select Personnel: Establish personnel responsible for manning the distribution of hazardous material and the collection, storage and disposal of hazardous waste.

S3-3: Institute Procedures: Establish procedures for hazardous material and waste management and ensure personnel are familiar with them. Ensure personnel are aware of existing materials and waste management plans and update such plans as necessary.

S3-4: Organize Construction Teams: Teams should be established which will construct or complete construction to various degrees on HazMart's and HWAP's.

R3 - Management Measures During Re-deployment

R3-1: Verify Final Disposition of Hazardous Substances: The final disposition of materials should be determined before withdrawing. Hazardous materials left in storage or in the workplace will exceed shelf lives and may become hazards. The same is true of hazardous wastes. Ensure that plans for disposing of hazardous wastes are in place.

R3-2: Relay Information to Replacements: If there are incoming personnel ensure they are aware of hazardous substance processing procedures and the status of management resources for which safety concerns remain.

Screening Constraints

As described in the literature review, the contingency environment is a potentially one of dynamic mission scenarios, imminent threat, high personnel turnover, high task loads, and low resource availability. A management system must be designed to survive and operate in such an environment. The following constraints must be met in order to

further ensure the success of such a system; a brief justification of the constraint is also detailed:

Economy of Time: Because of the increased workload on deployments tasks must be prioritized and accomplished quickly. Tasks which require considerable amounts of time will prevent other tasks from being accomplished. Personnel must be able to use a system quickly and efficiently.

Economy of Manning: Once again because of workload requirements available manpower will be at a minimum. The number of personnel dedicated to a management system must be kept as low as possible.

Economy of Fiscal Resources: This constraint is more one of today's Air Force than it is of contingency environments. Defense dollars are in short supply, particularly for new support functions. As a result, hard assets must be inexpensive and viewed as investments relative to the savings they produce when they are employed.

Simplicity: Due to dynamic mission environments personnel turnover on deployments may be high. Also, given the stress of increased workloads and the shortage of time, systems must be quickly understood and involve simple processes.

Expediency: Also a result of time and manpower constraints, systems must be quickly implemented and not require excessive work upon re-deployment.

Durability: Given the potential for hostile threat environments, a management system must be hardened and durable. Also, hard assets may be stored or unattended for long periods between deployments and thus must be able to exist without demanding excessive maintenance.

Flexibility: One of the most often heard quotes on Air Force contingency deployments is "flexibility is the key to air power." Dynamic mission environments require personnel and systems to adapt and overcome. Systems unable to adapt to new circumstances or requirements will fail.

Mission Capability: Lastly, a system must enhance not detract from the overall warfighting capability of deployed forces and must be prioritized properly in relation to other mission concerns.

The Screening Process

The alternatives presented in the previous section can be evaluated based on these constraints. As stated before, the problem is of an abstract nature and as a result a qualitative discussion, presented in this section, of the initiatives which are *frustrated* by these constraints and those which meet them is the chosen approach. The initiatives which best meet the constraints will then be available for further specification, optimization, and integration into a whole management system.

P1 - 1. ORI and ECAMP functions: While not necessarily contingency functions, these two auditing systems are performed regularly. Thus, further inspection of environmental contingency plans, programs, and assets would not require too much additional work. ECAMP is concerned with ensuring regulatory compliance before inspection by an outside agency and might not be suitable to focusing on functions outside the purview of such agencies. The ORI is specifically concerned with readiness and mission capability and because environmental factors may impact such concerns, this recurring inspection ought to give some focus to such measures.

P1 - 2. Theater Command Inspection: Given the funding constraints of today's Air Force, and the extensive duties of managing theater assets themselves, forward commands would probably not be willing to take on recurring inspections of deploying units. Forward bases, bare bases, and collocated operating bases themselves, are subject to recurring ORI's, which could fulfill environmental readiness auditing functions. This alternative is frustrated by funding and manpower constraints.

P1 - 3. Local Inspection: Wing personnel in these flights are already performing audits of existing hazardous materials and waste management functions on their installation. Making similar readiness planning and equipment inspections a part of these efforts would not be difficult.

P1 - 4. SORTS Reporting: Since the management of hazardous substances is part of deployment functions the training required, the capability to accomplish it in such an environment properly should be a subset of the overall SORTS reporting procedure.

D1 - 1. Frustrating Deployment of Units: This initiative would obviously, severely impact the arrival of forces into forward locations when they may be needed most. Warfighting capability would be seriously hampered. This alternative is frustrated by time and mission capability constraints.

D1 - 2. Inspection of Deploying Units: This initiative would also obviously slow deploying forces. The bottom line is that the deployment phase is not the time for conducting inspection. This alternative is frustrated by time and mission capability constraints.

S1 - 1. Theater Command Inspection: If threat conditions and mission environments are stable and there are concerns with hazardous materials and waste

management, this measure would obviously identify problems or provide assurance to theater commands responsible for managing installation after deploying forces leave.

S1 - 2. Local Inspection: Deployed bioenvironmental and safety personnel should definitely inspect methods and procedures for correctness to ensure that potential safety hazards do not result in mission impacts.

R1 - 1. Frustration of Unit Withdrawal: Theater Commands' experience with messes left behind by withdrawing forces, dictates that this initiative be used if there is reason to believe a problem may exist.

R1 - 2. Local Inspection: Such efforts would ensure against re-deployments being held up by host nations or Theater Commands.

P2 - 1. Development of physical assets up to deployable HWAP's and HazMart's: While such initiatives may seem to readily satisfy expediency and flexibility requirements one must compare them with the alternative of using existing resources to assemble deployment packages or construct such assets before or during contingency situations. Even fully functional HWAPs are nothing more than shelters with secondary containment and a supply of readily available safety equipment. Operating HazMart's are also essentially just storage warehouses with handling equipment, personal protective equipment, and safety equipment. Equipment brought along by deploying units is usually necessary for much higher priority initial taskings as discussed in the literature review. Adding equipment packages to already burdened units will slow down deployments unnecessarily. Establishment of complete HazMart and HWAP systems at bare bases will probably not be a subject of concern until the sustainment phase, when existing expedient

structures can be augmented with procured equipment supplies. This initiative is frustrated by cost, time, simplicity, and mission capability constraints because better methods exist.

P2 - 2. Assemble physical assets up to deployable HWAPs and HazMart's: Once again the argument against deployment packages is the simplicity of construction of these facilities. Mission priority does not dictate the quick employment of such operations. It is also doubtful that deploying forces could begin to require hazardous materials or generate hazardous wastes in such quantities before expedient structures could be established. This alternative is frustrated by time, cost, and mission capability constraints. Pre-assembled spill and safety equipment kits of various sizes to be shipped when needed during sustainment, however, will eliminate the process of separately procuring various items later.

P2 - 3. Theater Command Programming for HWAP and HazMart construction: Theater Commands are constantly reviewing base support plans for project programming purposes. If higher priority construction is complete in the pre-deployment phase before a contingency situation arises, construction requirements for HazMarts and HWAPs are fairly simple. A concrete pad sized according to expected material demand and waste generation rates with a means of secondary containment is basically all that is required. Softwall shelters put in place during sustainment can provide weather protection. Larger pads can be designed with bolts or supporting members in place for the sustainment phase construction of expedient hardwall structures if necessary.

P2 - 4. Acquisition of Computerized Information Management Tools: OSHA's HCS is designed to ensure that hazard, precautionary, and emergency information concerning hazardous material is available in workplace and storage locations and labeled

on packaging containers. While personnel may be familiar with the information concerning products with which they work on a regular basis, the availability of such data on an immediate basis can prevent or mitigate accidents, reduce risk and increase awareness. The availability of software systems which store reams of MSDS's, labels, and safety standards for instant printing was cited in the literature review. A laptop computer and a printer placed in a supply HazMart can quickly print such information and make it available when customers pick up materials. This eliminates the problems of procuring or bringing paperwork at forward locations from home installation organizations continuing with their own operations and which will probably have only one copy of the required MSDS available. Paperwork, specifically procuring and maintaining MSDS's, though essential to the supply of information, is the largest headache associated with hazardous materials. Though initial investment in required software and hardware may seem expensive, only one setup per a forward installation is needed, home installations can use the systems themselves, and the increased availability of information will further reduce the risks associated hazardous materials. Procurement of such systems specifically for contingency deployments would be a wise investment.

P2 - 5. Traditional Information Management Systems: In the absence of computerized information systems, notebooks containing appropriate MSDS's s, and label stocks should be a part of the deployment packages accompanying various wing functions. Notebooks require regular updating of information and are more prone to become dated, maintained improperly, or even lost.

D2 - 1. Construction of HWAPs and HazMarts: HWAPs and HazMarts are not crucial to flight operations, and therefore, their construction should be accomplished during the sustainment stage.

S2: Resource Measures in the Sustainment Phase

S2 - 1. Construction of HWAPs and HazMarts: As stated before HWAP's and HazMart's can be easily constructed during this phase using expedient softwall or hardwall shelters. Preparation of spill kits, personal protective equipment, and safety equipment for deployment packages is probably a good idea and would save procurement time once deployed.

S2 - 2. Develop and Establish Base Disposal Capability: The cost of procuring an on base treatment system and dedicating and training personnel for its use will probably be considerably higher than even flying hazardous wastes to locations where contracted disposal can be procured if it is not available at the forward base. The issue of which wastes are treatable must also be raised. Incinerators, land treatments, thermal treatments, chemical, physical, and biologic treatments require substantial commitments of personnel, time, and funds. The Air Force should continue to contract for disposal or transport wastes to installations where such contracts are in place. This alternative s frustrated due to time, manpower, and funding constraints.

R2 - 1. Provide Proper Packaging for Hazardous Substance Transport: It is unfortunately almost inevitable that unmarked or decaying drums and make shift hazardous waste drum storage sites turn up on deployments. If samples cannot be procured for unmarked drums or contracted disposal is not available, airlift may be the only answer. While vigilance on the part of leadership, safety, and environmental

personnel can reduce such problems, a good supply of overpacks and empty, new drums should be pre-positioned on base.

P3: Management Measures in the Pre-Deployment Phase

P3 - 1. Base Support Planning: HWAP's and HazMart's should be a part of a base support plan. Siting with quantity distance criteria in mind away from key assets, base population centers, and water sources is a good idea. Establishing where such facilities fall in tasking priorities eliminates later problems. It should be noted that base facilities with concrete floors, adequate indoor spacing, and a means of secondary containment can quickly become operational HazMarts or HWAPs if stocked with appropriate equipment. Supply warehouses for non-hazardous materials can also be used for hazardous material storage if properly equipped. Also of note is the lack of fire suppression systems in such facilities or expedient facilities described earlier. Such systems at forward bases are rare in any facility and may not be maintained properly or at all. Initial planning should be viewed as investment in forecasting and eliminating future problems.

P3 - 2. Develop a Hazardous Materials and Waste Management Plan: In addition to HWAP and HazMart siting and facility considerations and material and waste processing procedures, the Hazardous Materials and Waste Management Plan appendix to the BSP or other deployment plans should include a spill response plan with appropriate lists of personnel to contact.

P3 - 3. Organize HCS and RCRA Training Sessions: Management methods which ensure proper training and knowledge of contingency procedures, increase

awareness, reduce risk and prevent accidents thus positively impacting mission capability. Pre-deployment briefs should cover such issues.

D3. Management Measures in the Deployment Phase

D3 - 1. Stress Awareness: This should be accomplished as best possible in the pre-deployment phase and followed up on in the sustainment phase. Time constraints probably do not permit formal measures during actual deployment.

D3 - 2. Select Personnel: Establishing personnel responsible for manning the distribution of hazardous material and the collection, storage and disposal of hazardous waste should be established in deployment or hazardous materials and waste management plans. Personnel should probably not be dedicated to this duty until the sustainment phase. This initiative is frustrated by time constraints.

D3-3: Institute Procedures: Procedures should be established in plans before deployment. Instituting procedures should wait until sustainment. Deployments require concentration to be focused elsewhere. This initiative is frustrated by time constraints.

D3-4: Organize Construction Teams: Deployments to bare bases will require construction teams and assets to be dedicated to higher priority tasks than building or completing HWAP's and HazMart's in this phase

S3-1: Stress Awareness: During times of decreased threats and static mission environments, training sessions should be employed to make deployed personnel aware of hazards, precautions, and emergency actions in addition to spill response procedures.

S3-2: Select Personnel: After completing higher priority deployment duties personnel can be dedicated to the tasks of managing the distribution of hazardous

materials and the collection of hazardous wastes. Dedicated personnel will aid in the institution of proper handling procedures, thus reducing risk.

S3-3: Institute Procedures: Once the deployment phase is over, establishing, communicating, and enforcing hazardous materials and waste management procedures can take place. Established procedures should facilitate safer management of hazardous substances. More exact specifications of recommended procedures will be presented in the optimization section.

S3-4: Organize Construction Teams: As previously stated this is the appropriate time period for establishment or improvement of HWAP's and HazMart's

R3-1: Verify Final Disposition of Hazardous Substances: This is essential in preventing messes that will have to be cleaned up later and is worth the time and effort.

R3-2: Relay Information to Replacements: This is essential to ensuring the continued safe handling and processing of hazardous materials and wastes.

Commentary

This process of screening alternatives may seem simplistic, rambling or repetitive, but it aids in focus ideas and grouping alternatives. Repetition is occurring because some alternatives are naturally grouped together in sets accomplishing the same overall objective. The length and tedious but simplistic nature of the process is a result of a rigorous methodology which attempts to address all facets of a problem. Some alternatives may seem to be intuitively bad ideas but the brainstorming process spurs generation by not initially eliminating initiatives. The presentation of some alternatives may seem very broadly defined, and the discussion in the screening process may not seem

specific. This is a result of the a rigorous methodology being applied to the creative process. Focus and specificity will be developed in the grouping and optimization process presented next. Fig. 4-4 summarizes the screening process.

Fig 4-4.

The Screening Process

The Alternatives:	Time	Manning	Funding	Simplicity	Expediency	Durability	Flexibility	Mission Capability
P1-1								
P1-2		X	X					
P1-3								
P1-4								
D1-1	X							X
D1-2	X							X
S1-1								
S1-2								
R1-1								
R1-2								
P2-1	X		X	X				X
P2-2								
P2-3								
P2-4								
P2-5								
D2-1	X							X
S2-1								
S2-2	X	X	X	X			X	X
R2-1								
P3-1								
P3-2								
P3-3								
D3-1	X							X
D3-2	X							X
D3-3	X							X
D3-4	X							X
S3-1								
S3-2								
S3-3								
S3-4								
R3-1								
R3-2								

(The Constraints: Time, Manning, Funding, Simplicity, Expediency, Durability, Flexibility, Mission Capability)

Eliminated alternatives marked by frustrating constraint

Grouping

The purpose of this step in the development process, as stated before, is to take the disjointed individual alternatives and classify them into more holistic and basic categories. These classifications will first provide some clarity and summary at the end of the development process and secondly will allow one to outline a basis for actual practical steps to be taken in implementing a hazardous materials and waste management system into contingency environments.

The following, alternatives detailed with the phase in which they should be implemented, remain after the screening process:

P1 - 1: ORI
P1 - 3: Local Inspection
P1 - 4: SORTS Reporting
S1 - 1: Theater Command Inspection
S1 - 2: Local Inspection
R1 - 1: Frustration of Unit Withdrawal
R1 - 2: Local Inspection
P2 - 3: Theater Command Programming for HWAP and HazMart construction
P2 - 4: Acquisition of Computerized Information Management Tools
P2 - 5: Traditional Information Management Systems
S2 - 1: Construction of HWAP's and HazMart's
R2 - 1: Provide Proper Packaging for Hazardous Substance Transport
P3 - 1: Base Support Planning
P3 - 2: Develop a Hazardous Materials and Waste Management Plan
P3 - 3: Organize HCS and RCRA Training Sessions
S3 - 1: Stress Awareness
S3 - 2: Select Personnel
S3 - 3: Institute Procedures.
S3 - 4: Organize Construction Teams
R3 - 1: Verify Final Disposition of Hazardous Substances
R3 - 2: Relay Information to Replacements

These initiatives can be grouped into four basic supersets: planning efforts, construction and equipping of hard assets, somewhat miscellaneous good management practices, and inspection or assessment efforts. While it may seem that each of these groupings falls into the formalized, general management subdivisions of planning, organizing, leading, and controlling, each, except for the disperse management propositions, are very specifically related to the more focused type of classification mentioned. Planning efforts seem to be separated from other alternatives mainly by the timing of their implementation, the pre-deployment stage. Construction specifications for expedient hazardous materials and temporary waste storage facilities, along with corresponding deployable equipment packages for such facilities, clearly fall under the heading of physical assets. Finally, a number of the initiatives are simply different means of assessing a management system to ensure its proper function.

In attempting to provide some order to the diverse list of good management procedures, it should be noted that each of these initiatives will have to relate directly to the physical assets personnel will have to use in the field. Thus, the management practices and procedures should be classified into the same category with the construction and equipping of physical assets. This leaves three basic categories of initiatives: specifications for the construction and equipping of, and development of procedures for the use of physical assets; contingency planning initiatives; and assessment efforts. Given the almost tedious, detailed screening process applied to every single alternative, the grouping process may seem relatively short. The reader should note that the two steps are unrelated in the time and depth required for their accomplishment and should not conclude that the

lentgh of the screening process necessitates an extensive grouping step. The following listing shows the grouping of the measures which survived the screening process:

Specifications and Procedures for the use of Hard Assets
P2 - 3. Theater Command Programming for HWAP and HazMart construction
P2 - 4. Acquisition of Computerized Information Management Tools
P2 - 5. Traditional Information Management Systems
S2 - 1. Construction of HWAPs and HazMarts
R2 - 1. Provide Proper Packaging for Hazardous Substance Transport
S3 - 3. Institute Procedures
S3 - 4. Organize Construction Teams

Contingency Planning Alternatives
P3 - 1. Base Support Planning
P3 - 2. Develop a Hazardous Materials and Waste Management Plan

Assessment Alternatives

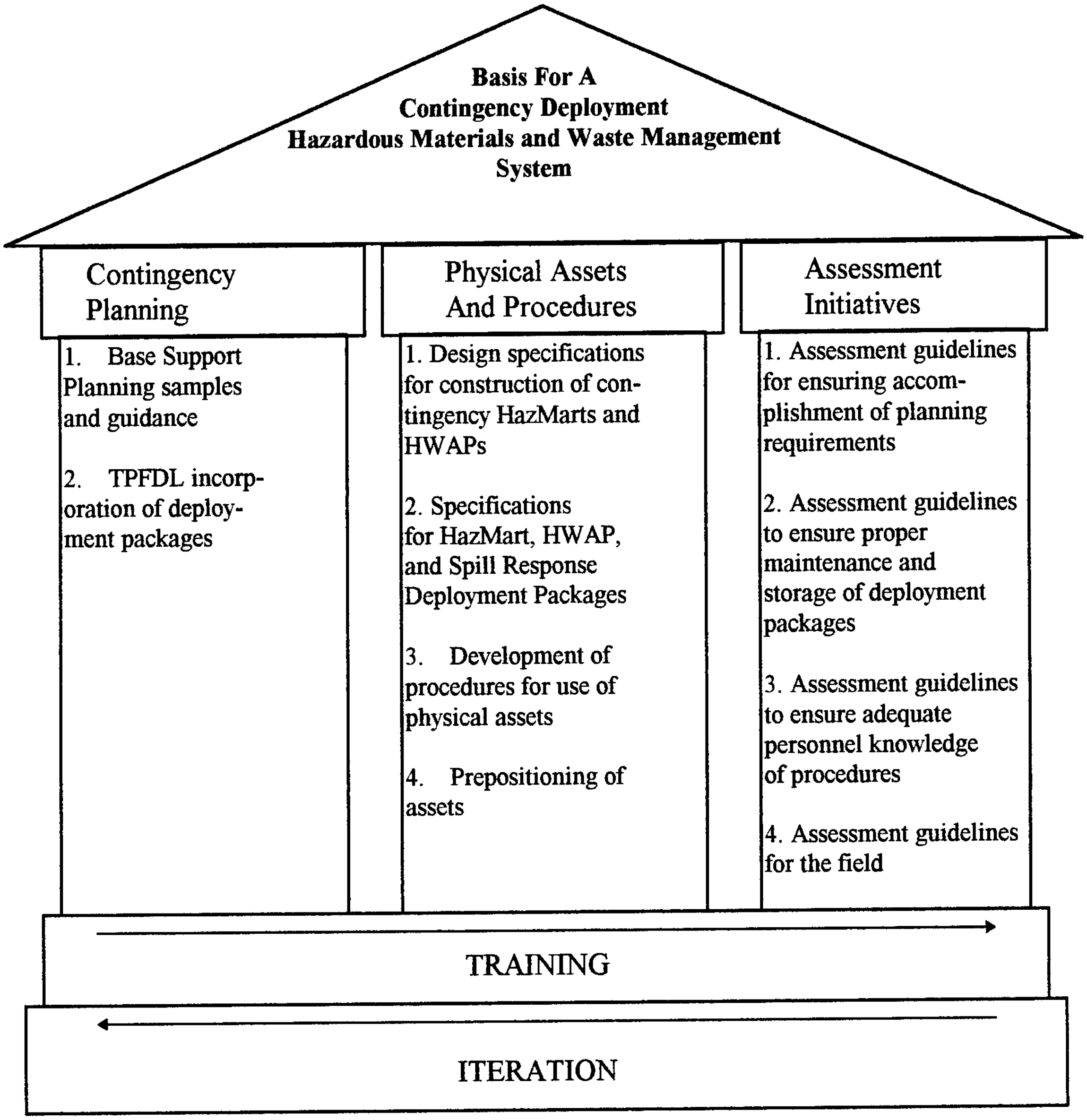
External to Deploying Forces	Internal to Deploying Forces
P1 - 1. ORI	P1 - 3. Local Inspection
P1 - 4. SORTS Reporting	S1 - 2. Local Inspection
S1 - 1. TheaCom Inspection	R1 - 2. Local Inspection
R1 - 1. Frustration of Unit Withdrawal	P3 - 3. Organize HCS and RCRA Training Sessions
	R3 - 1. Verify Final Disposition of Hazardous Substances
	R3 - 2. Relay Information to Replacements

The Final Product

Pillars seem to be the military's analogy of choice for explaining environmental efforts and can be used here to illustrate the final product of this research, a basis for a hazardous materials and waste management system for Air Force contingency deployments (See Figure 4-4). As stated above, the basic three pillars supporting the system would be: contingency planning efforts; the construction of, equipping of, and

procedures for use of hard physical assets; and assessment efforts to ensure the proper implementation of the measures falling under the other groupings.

Fig. 4-5


Basis For A
Contingency Deployment
Hazardous Materials and Waste Management
System
Contingency Planning
1. Base Support Planning samples and guidance
2. TPFDL incorporation of deployment packages
Physical Assets And Procedures
1. Design specifications for construction of contingency HazMarts and HWAPs
2. Specifications for HazMart, HWAP, and Spill Response Deployment Packages
3. Development of procedures for use of physical assets
4. Prepositioning of assets
Assessment Initiatives
1. Assessment guidelines for ensuring accomplishment of planning requirements
2. Assessment guidelines to ensure proper maintenance and storage of deployment packages
3. Assessment guidelines to ensure adequate personnel knowledge of procedures
4. Assessment guidelines for the field
TRAINING
ITERATION

One should note that although their is a sequential order in the categories of implementation (planning, doing, assessing) it is not necessarily related to the time phases of deployment; several of the practical measures may take place throughout the deployment process. Practical steps which could be taken in this category are listed also. Guidelines or checklists are the traditional tools used by the Air Force for assessment efforts. These could be developed by Major Commands, the Air Staff, or Air Force support agencies. As was noted in the discussion in the screening step of the development process, the deployment phase is no time to conduct an inspection. Time and more important mission priorities obviously prohibit such efforts. Assessment efforts should take place primarily in the pre-deployment stage and during extended periods of sustainment, when there is time to concentrate on such activities and higher priority actions have been completed or when circumstances indicate the need for such measures. Deployed commanders should make the decision regarding if and when such measures should be employed.

One final note regarding assessment efforts should be made regarding accountability to correct problems detected during individual inspections. As with most other forms of military inspection, the subsequent follow-up ensuring problem correction is a leadership issue. Responding to findings is directly related to emphasis placed upon the subject by local wing commanders and theater commands. Developing specific legal requirements to enforce such responses is unnecessary and would be difficult to apply given the contingency environment. The usual legal tools with which commanders may

enforce their will (specific orders, *failure to go*, *dereliction of duty*, *failure to obey an order*, and other Article 15 measures) of course, are always applicable.

Planning initiatives ensure that prior to the deployment, issues have been addressed and limiting factors have been identified. Two specific traditional Air Force planning mechanisms are the BSP and TPFDL. Examples of appropriate addendums to BSPs should be developed and distributed to wings by Major Commands, the Air Staff, or support agencies. Forward commands should also plan to incorporate deployment packages into TPFDLs. Plans should be updated as required and personnel should be familiarized with them.

Physical assets represent the third pillar supporting the basis for a management system. Practical recommendations include the development of standardized specifications for constructable storage facilities, which take compatibility, secondary containment, ventilation and other such requirements into account. As discussed in the screening step of the development process, this research favors constructable expedient facilities over fully deployable packages. Air Force support agencies should develop deployable UTC equipment support packages for such facilities. Packages should include the various types of equipment discussed in the corresponding section of the literature review in this thesis. Support agencies should also develop procedural guidelines for storage, distribution, information management, and disposal of hazardous substances during deployments. Lastly, physical assets will have to be prepositioned or programmed by Theater Commands.

Finally, no management system can be properly developed without a good foundation of personnel trained in its use and the understanding that the iterative, trial-

and-error, process will refine and improve the system. Some training measures will have to be employed to ensure personnel are familiar with physical assets and their accompanying usage procedures and developed assessment and planning practices. Initial trials of any of the practical recommendations will point out both areas of success and concern which can be honed and corrected in further iterations. These two factors, iteration and training, are shown as crucial footings supporting the three pillars of the proposed basis for a hazardous materials and waste management system for contingency deployments.

Chapter V

Conclusions and Recommendations

Overview

As environmental awareness and corresponding programs in the Air Force grew in recent decades, individuals and institutions gained a better understanding of the potential risks associated with the handling and processing of hazardous materials and wastes. Measures were initially taken by the Air Force to comply with standards at peacetime-established operating bases primarily because non-compliance resulted in mission impact through regulatory enforcement. But the establishment of such measures at home, along with negative experiences in the field where such measures were less established, has led Air Force and Major Command staffs to become interested the development of management solutions which can be established in the field.

This research focused on developing a basis for an integrated hazardous materials and waste management system for field deployments. The literature research established the necessity of such a system, characterized the contingency environment, reviewed applicable laws and regulations to determine the basis for underlying safety concerns, reviewed general precautionary methods for the handling and processing of hazardous wastes, and reviewed current equipment resources which could be employed in a deployable system.

General design morphologies were then studied and brought together into a methodology for analyzing the problem. Having already verified existence of a need for a contingency management system and defined the basic objective, a characterization of the problem was developed by comparing the life cycle flows of hazardous materials and wastes in the peacetime CONUS base environment with those in the deployed contingency environment. This exercise established three basic factors -- regulatory controls, resource controls, and management controls -- which reduce risk of control failures and resultant adverse mission impacts are found in varying, typically inadequate, degrees in the contingency environment.

These controlling factors were then crossed in matrix form with the four phases of most deployments -- pre-deployment, deployment, sustainment, and re-deployment -- to provide a framework for generating alternatives for further evaluation. The characterization of the contingency environment developed in the literature review was then used to establish the constraints a management system would have to satisfy. These constraints were then employed in a lengthy, qualitative screening process, to reject alternatives which would not be suitable for deployments. The surviving initiatives were then grouped into three interacting categories: the construction and equipping of hazardous material storage pharmacies and hazardous waste accumulation points with hard assets, personnel, and established procedures; contingency planning guidelines; and external and internal assessment programs to ensure the proper employment of the other two categories and target areas for improvement. It may be said that these categories form the basis or *pillars* supporting further optimization and practical development of an

integrated hazardous materials and waste management system for contingency deployments.

Commentary, Implementation, and Further Research Recommendations

The initial aim of this research was to not only to provide the basis for the development of a hazardous materials and waste management system, but to detail and specify the actual practical components of such a basis. After struggling with how to approach a qualitative design problem methodically, implementing the chosen means of analysis also proved tedious and difficult. This was a result of the intuitive, creative process being confined to a rigorous screening analysis. The grouping process which followed did, however, bring surviving, seemingly discordant alternatives, into a solid foundation for optimizing general initiatives into specific implementational measures.

Developing practical, specific measures, however, required more extensive literature review and expert consultation. Appropriate specification of expedient construction requirements for hazardous material pharmacies and waste accumulation points, development of requirements for support equipment in correctly sized deployable Unit Type Code packages, development of contingency procedural guidelines for materials and waste processing in an Air Force Instruction format, development of an OEBGD protocol for regular inspection and self assessment in these areas of concern, and development of specific contingency plan requirements, though eagerly attempted after the establishment of a basis for a management system, proved beyond the scope of one thesis. Each of these focused areas are recommended for future development, and integration into

a hazardous materials and waste management system for contingency deployments based on the research completed here.

Such work is probably not ideal for future research but should be developed by Air Force staffing agencies. Specifically, the broad description of the management system should be coordinated on and adopted by the representatives of all the functional components of deploying Air Wings at the Air Staff level, in much the same way as the traditional four-pillared environmental strategy has been adopted.

The specific, practical implementational recommendations given in Chapter IV should be taken as action items by Air Force support staffs after the general system description has been embraced by Air Force leadership. Good existing hazardous materials and waste plans such as that in Appendix A, already exist; general guidelines for such plans should be developed by the Air Force Civil Engineering Support Agency in concert with the logistics community at the Air Staff and Theater Commands. The same organizations should also take on the tasks of designing specifications for the construction of contingency HWAPs and HazMarts, developing the corresponding facility support equipment deployment packages, and developing the procedures for the use of such hard assets. Logistics planners at the Theater Command and numbered Air Force level would then be responsible for incorporating deployment packages into the appropriate TPFDL and pre-positioning such assets in the field as necessary. These planners should also be responsible for augmenting existing assessment measures which ensure proper planning has been accomplished, to ensure that these new requirements have been fulfilled. Staffing support agencies for bioenvironmental, civil engineering, and supply functions should also develop assessment checklists which can then be used in the field to ensure developed

procedures are being followed, and findings of non-adherence are documented and communicated to commanders. Similarly, such assessment measures must be developed by these organizations ensuring that personnel have adequate knowledge of such procedures and that deployment packages are maintained and stored properly. Finally, deployment training programs for all Air Force personnel must be augmented with contingency hazardous materials and waste processing lessons developed by the corresponding training organizations. Obviously, a great deal overlap and dual responsibility is likely amongst the three primary cited wing functional elements, bioenvironmental engineering, civil engineering, and logistics and other operational components of deploying wings. Outlining of specific responsibilities, and calls for the necessary cooperation will have to come from the leadership during the initial adoption and coordination of the management system.

An interesting, unanticipated side result produced in the screening process was the favoring of expedient construction of hazardous substance storage facilities over development of deployable assets. Such facilities are not nearly as complex as anticipated, nor are they immediately required on deployments. As a result, basic expedient construction of sheltered, secondary containment systems was chosen as the better alternative. As companies are currently marketing deployable trailers and shelving to the Navy and consideration to development of similar assets is being given by the Air Force, further debate and assessment of the issue would be an interesting focus of discussion at the staffing level.

Finally, the current development of information systems, cited in the literature review, which have the capabilities of producing MSDSs and appropriate labeling on

demand and being updated on a regular basis, was surprising. Analysis of Air Force compliance violation notices and ECAMP findings repeatedly cite basic paperwork management as a recurring problem even at established operating bases. Information distribution and availability is a key component of exposure prevention and accident mitigation and is the primary focus of the OSHA Hazardous Communication Standard. The potential for the computer to revolutionize the paperwork morass associated with hazardous materials and waste management and further improve information flow to workers seems very high.

Thesis research into this area to evaluate existing systems or develop specifications for Air Force solicitation of such products could be very rewarding and of considerable value. A methodology similar to the one used here to screen alternatives could be employed to compare existing information management systems or to develop specific requirements for an Air Force system.

Appendix A

Hazardous Material and Waste Management Plan

Exercise Bright Star 95

PURPOSE

To establish procedures for the management, collection, segregation, and disposal of materials identified as Hazardous Waste and/or Hazardous Materials (HW/HM). The HM/HW will be disposed of during and after Exercise Bright Star 95. All disposal will be conducted in accordance with the Host Nation contract.

GUIDING PRINCIPLES

Environmental protection, control of hazardous materials and hazardous waste (HW/HM), and environmental restoration are the responsibility of each commander and individual soldier. The use and production of HM/HW is a part of normal activities and cannot be eliminated. However, compliance with the procedures and policies outlined in this plan will reduce exposure and limit contamination by these substances.

Although the Host Nation does not have the stringent environmental laws found in the United States, all units deployed to Bright Star AB will still be held to the standards of DoD policy and regulations, derived from U. S. Public Law and Regulations.

DEFINITIONS

Hazardous materials are defined as material meeting the conditions listed below. They become hazardous waste when discarded after their intended use. These discarded materials are subject to Resource Conservation Recovery Act (RCRA) regulations.

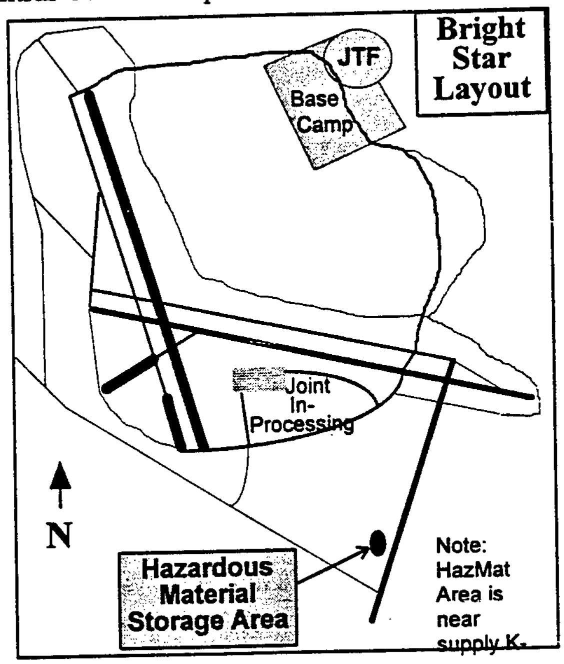
Conditions for classifying a material as hazardous:

- All materials included in the United States Environmental Protection Agency (USEPA) hazardous waste list.
- Materials, though not specifically listed as hazardous, which exhibit at least one of the following characteristics:

    1. A liquid having a flashpoint of less than one hundred forty (140) degrees Farenheight or sixty (60) degrees Celsius.
    2. A non-liquid which will cause a fire through friction, absorption of moisture, or is liable to ignite and burn vigorously and persistently.
    3. Corrosives: Aqueous liquids (water soluble) having a pH equal to or less than 2.0 **or** having a pH equal to or greater than 12.5.
    4. Reactivity: Substances which can undrego violent chemical changes, react violently, form an explosive mixture with water, or explode at normal room temperature and pressure.
    5. EP Toxicity: Solid wastes which exhibit the characteristics of EP toxicity when extracts from representative samples of the material contain any of the contaminants identified in 40 CFR, part 261.1, at a concentration equal to or greater than the value stated in that document.

COLLECTION POINT AND STORAGE AREA

There will be one Hazardous Material (HazMat) Storage Area on Bright Star AB, see map for location. This Storage Area will serve as the central collection point for all hazardous wastes. The Storage Area will be manned by the HazMat Team attached to the USAF 366th Civil Engineer Squadron: OIC is 1 Lt Erik Larson, NCOIC is SSgt Thomas Wilson.



General Hours of Operation

The HazMat Storage Area will be open for waste turn-in between 0800 and 1100 on the following days:

18 Sep - 15 Oct................................Mon
16 Oct - 17 Nov...............Mon, Wed, Fri
18 Nov - 4 Dec.................................Mon

Contact prior to turn-in is recommended, as hours of operation are subject to change without notice. Appointments outside these times will be accommodated if possible.

Containment and Segregation

The HazMat Storage Area will provide adequate spill containment for drums containing hazardous waste and hazardous materials (HWHM) while providing sufficient space for segregation of HW/HM by compatibility. The HW/HM will be segregated into six (6) different areas:

1. Oil and Petroleum Products (contaminated fuels, oil, transmission fluid, grease, AOAP oil samples) in metal drums.
2. Ethylene Glycol (antifreeze) in metal drums.
3. Solid Materials (lithium batteries, Class V residue, oil and fuel filters) in metal drums.
4. Flammable Liquids (brake fluid, paint thinner) in metal drums.
5. Silver Nitrate (photograpic fluid) in plastic containers.
6. Lead Acid Batteries on separate pallet with spill protection (plastic sheeting/diking).

Note: Acids, bases, or chemical mixtures will be stored separately in plastic containers at least three (3) feet from incompatible materials, with adequate diking and spill protection.

There may be HW/HM items used at Bright Star AB which are not addressed by this plan. This HW/HM must be handled separately and not mixed under any circumstances.

Labeling of Drums

Hazardous material labels will be available at the HazMat Storage Area. These labels are the preferred method of indicating drum contents. However, paint pens or stencils may be used for labeling. All drums turned in to the HazMat Storage Area must be labeled with the following information:

1. Chemical Name or Shipping Name.
2. Responsible Point of Contact.
3. Date when first waste product was placed in the drum.

Turn-in Procedures

Each customer must submit a DD Form 1348-1 each time HW/HM is brought to the HazMat Storage Area. The HazMat Team will have these forms available at the Storage Area. An example copy of DD Form 1348-1 is attached at Annex A.

Distribution of DD Form 1348-1 is as follows:

1. The original copy is sent by the HazMat Team to the Army Principal Assistant for Contracting (PARC) Office. The PARC will be responsible for distribution of cost to the responsible military department agency.
2. The second and third copies are kept by the HazMat Team.
3. The fourth copy is kept by the customer.

Design and Construction of Storage Area

The HazMat Storage Area will be constructed in the vicinity of the supply K-span buildings on Bright Star AB by the 823rd Red Horse Squadron, USAF by 15 September 1995. The storage area will be approximately 30 feet by 40 feet with a 12 inch high berm and plastic sheeting to protect the environment in the event of a spill. The storage area will be excavated from the ground surface.

The front section of the berm will be designed to slope to allow easy access by the customer and the Host Nation contractor and allow a forklift to move the pallets. The spill area provides 1200 cubic feet for spillage to meet the fifty (50) percent spill containment rule.

A minimum of five separate pallets will be used to segregate the various classes of hazardous waste and hazardous material (HW/HM) identified in this plan. The area will be encircled by a chain-link fence and have a securited gate with an electric light to prevent the disposal of HW/HM after hours.

Storage Area Equipment Requirements

The following equipment contained in the HazMat Team Kit comprises the minimum requirements for HazMat Storage Area daily operations:

1. Funnels -- Approx. 1 1/2 inches at nozzle end, 12 inches at open end.
2. Drums, Plastic -- Four (4) each, fifty (50) gallon.
3. Drums, Steel -- Twelve (12) each, closed head type.
4. Pallets -- Four (4) each, 48 inches by 48 inches.

HOST NATION CONTRACT

Contracting personnel will work an uncomplicated contract. The Host Nation contractor, National Service Projects Organizations (NSPO), will perform HM/HW disposal at the cost of US Dollar 200.00 per truckload with no stipulations. The contract has been written by Major Clemons, assigned to the ARCENT Contracting Section, with a SOW written by ARCENT Environmental Section (AFRD-EN), and was forwarded to Col Carr of ARCENT Contracting for his approval and Host Nation concurrence.

The contractor will supply necessary drums to the storage area, and will pick up hazardous waste and hazardous material as required on an on-call basis. Pick up dates are tentatively scheduled for 27 Oct, 17 Nov, and 7 Dec.

Normal Host Nation Pick Up Procedure

When pick up is required, the HazMat Team at Bright Star AB will contact the PARC Office five (5) days prior to pick up. Contact is either through the host unit contractor or the AFFOR contractor. A date and time will be coordinated with the Host Nation contractor for pick up.

All hazardous waste and hazardous material turned over to the Host Nation contractor will be manifested, Material Safety Data Sheets will be supplied, and proper paperwork will be completed (DD Form 1348-1). The driver must sign the form acknowledging receipt of the material. Copy 1 of the DD Form 1348-1 will be sent to the PARC Office. Copy 2 will be retained by the HazMat Team for their records. Copy 3 will be given to the Host Nation contractor.

Final Host Nation Pick Up Procedure

The Host Nation contractor will pick up all remaining hazardous material, hazardous waste, and drums at final close out of the Hazardous Material Storage Area. Drum bungs must be tightened at all times.

Equipment Required for Host Nation Pick Up

The following equipment must be on hand at the Hazardous Material Storage Area when the Host Nation contractor arrives for pick up:

1. 4K Forklift, 1 each.
2. 5KW Generator set at 50 MHz, 1 each.

SAFETY AND COMPLIANCE

Safety should be given top priority during handling and disposal of hazardous waste and hazardous material. The following guidelines apply at all times:

1. Do not mix chemicals.
2. Use proper containers for storage.
3. Drive carefully when transporting hazardous waste and hazardous material.

All personnel deployed to Bright Star AB must comply with the policies and procedures outlined in this plan. A pamphlet outlining the information contained in this plan will be distributed to all units deploying to Bright Star AB prior to their departure. This pamphlet is attached at Annex B.

Unit Environmental Coordinators

All units deploying to Bright Star AB must identify a primary and alternate Unit Environmental Coordinator (UEC) to act as a points of contact for all environmental issues, including HazMat storage and disposal. The names of these UECs must be provided to the Bright Star HazMat Team ***no later than 1 Sep 95***. The UECs will work with the HazMat Team ensure their units meet all applicable regulations and guidance on storage, spill response, and disposal of hazardous waste and hazardous materials.

Bright Star HazMat Team Kit

The following items are included in the palletized Bright Star HazMat Team Kit:

Containment Equipment & Material	
85 gal. plastic overpacks	3 ea.
55 gal. plastic drums (battery debris)	5 ea.
55 gal. steel drums, closed top	10 ea. (to start, will be procured in-theater)
55 gal. steel drums, open top	5 ea. (to start, will be procured in-theater)
Absorbant booms	1 box
Absorbant pillows	1 box
Soda Ash (50 lb bags)	5 ea.
Oil Dry (50 lb bags)	25 ea.
50 gal. plastic bags	100 ct.

Team kit container, 4’ x 5’ x 2.5’ heavy gage covered steel box, doubles as HazMat containment

General Equipment & Tools

- Hand tools (sockets & wrenches)
- Mechanical drum pump
- Electric pump
- Drum dolly
- Bung wrench
- Portable eyewash
- Cargo straps
- Shovels
- Brooms
- Drum hook (for forklifting)
- Grease pencils
- Paint markers
- Duct tape

Personal Protective Equipment

- Leather gloves
- Stanzoil neoprene acid resistant gloves
- Tyvek suits
- Paper suits
- Face suits
- Goggles
- Respirators & filters
- Testing capabilities kit
- Latex gloves

Paperwork

- Labels -- HW, Non-HW, Empty
- Profiles
- Brochures
- Manifests
- MSDSs for batteries, oils, paints and related materials

Hazardous Material Spill Plans

All hazardous materials should be stored in clearly labeled, sealed containers with an appropriate MSDS on file. The impact of potential spills should be limited through double containment or dikes. Hazardous materials and hazardous wastes should be stored away from drains and water sources to limit potential contamination. All personnel must know what to do in case of a spill:

1. Contact the fire department. Provide information on the location, type of material, and amount of spill.
2. Contain the spill if possible.
3. Evacuate the area.
4. Contact the HazMat Team for clean-up.

Spill Kits

A spill kit will be maintained at the Hazardous Material Storage Area for use on Bright Star AB. The minumum equipment requirements for the spill kit are as follows:

1. Fifty-five (55) gallon open head drums, 2 each.
2. Shovels.
3. Brooms.
4. Bags of oil absorbent material (kitty litter, oil dry).

Spill Clean-Up

Clean-up of spills at Bright Star AB will be coordinated by the in place USAF HazMat Team with guidance from USCENTAF and in-theater commanders. Clean-up procedures will be tailored to the specific event, and include techniques such as land farming and actual disposal of contaminated soil.

POINTS OF CONTACT

USCENTAF/A1-CEX
Capt Tim Fuller
Requirements and Environmental Engineering
Voice DSN: 965-3249
Fax DSN: 965-3861
E-mail: a1cexv@hq.centaf.af.mil

ARCENT/AFRD-EN
Mr Rod Collins
Environmental Management
Voice DSN: 572-4829
Fax DSN: 572-3375
E-mail: collinsr@ftmcphsn-emh1.army.mil

Bright Star HazMat Team
1 Lt Erik Larson
Environmental Management OIC
Voice DSN: 787-6964
Fax DSN: 986-1595
E-mail: larsone@wrightpatterson-de.af.mil

ARCENT Contracting (3rd Army)
Maj John Clemons
Voice DSN: 572-3222
Fax DSN: 572-4896

ANNEX A

SAMPLE DD FORM 1348-1

ANNEX B

Hazardous Materials
and
Waste Management
Guidance Pamphlet

Bright Star 95

PURPOSE

This pamphlet offers guidance on hazardous material (HazMat) policies and procedures at Bright Star AB during the course of Bright Star 95. All US and DoD HazMat regulations will apply to units deployed to Bright Star in accordance with the DoD policy of "fully integrating environmental considerations into our defense policy...ensuring that we protect the environment during military operations." The guidance offered in this pamphlet is a basic outline of HazMat procedures that must be followed by all units on Bright Star AB. Specific questions can be directed to the USAF Civil Engineering points of contact listed at the end of this pamphlet. Each commander and individual soldier on Bright Star AB is responsible for protection of the environment and proper storage of hazardous materials and disposal of hazardous waste.

Definition of Hazardous Materials

Hazardous materials (HazMat) include petroleum, oil, and lubricants (POL), lithium and lead acid batteries, ethylene glycol (anti-freeze), paints, and silver nitrate from photography. Flammable, corrosive, chemically reactive, and toxic substances should be considered hazardous materials. If in doubt, consider it HazMat.

HazMat Minimization

Every effort should be made to reduce the amount of hazardous materials requiring disposal on Bright Star AB.

HazMat Storage

All hazardous materials should be stored in clearly labeled, sealed containers with an appropriate MSDS on file. Incompatible materials must be stored separately--contact HazMat Team for guidance. The impact of potential spills should be limited through double containment or dikes. Spill kits should be maintained near storage areas.

HazMat Spill Plans

Proper storage and handling of hazardous materials should limit the risk of spills. However, all personnel must know what to do in case of a HazMat spill:

1) Contact the fire department. Provide information on the location, type of material, and amount of spill.
2) Contain the spill if possible.
3) Evacuate the area.
4) Contact the HazMat Team for clean-up.

HazMat Labeling Requirements

Labels can be obtained from the HazMat Storage Area upon arrival at Bright Star. All drums must be labeled with proper shipping name of contents, the date the first material was placed in the drum, and the responsible point of contact. Use stencils or paint pens if no labels are available.

HazMat Disposal & Turn-in Procedures

Do not dispose of hazardous waste with regular trash, by dumping down drains, or by pouring on the ground. Drums containing hazardous materials must be turned in to the HazMat Storage Area near the supply K-span buildings. Remember: a Material Safety Data Sheet (MSDS) is required for all hazardous waste turn-ins.

HazMat Storage Area Hours

The Bright Star HazMat Storage Area will be available for waste turn-in between 0800 and 1100 on the following days:

18Sep - 15 Oct................................Mon
16 Oct - 17 Nov................Mon, Wed, Fri
18Nov- 4 Dec................................Mon

Contact prior to turn-in is recommended. Appointments outside these times will be accommodated if possible.

Unit Environmental Coordinators

All units deploying to Bright Star must identify a primary and alternate Unit Environmental Coordinator (UEC) to act as a points of contact for all environmental issues, including HazMat storage and disposal. The names of these UECs must be provided to the Bright Star HazMat Team ***no later than 1 Sep 95*** -- phone numbers are listed at the end of this pamphlet. The UECs will ensure their units meet all applicable regulations and

Hazardous Material Checklist

Pre-Employment:

- Bring Material Safety Data Sheets (MSDS) for all Hazardous Materials.
- Train personnel on HazMat minimization, control, and turn-in.
- Train personnel on reporting of HazMat spills: who to call and what to do.
- Identify a single HazMat point of contact for your unit to Bright Star USAF Civil Engineering.

In-Theater:

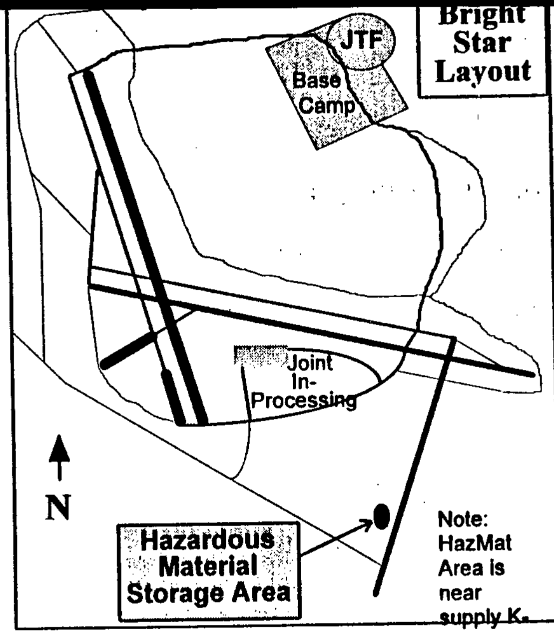
- Obtain storage drums and labels from Bright Star HazMat Storage Area.
- Obtain spill kits from HazMat Team as needed.
- Keep records of materials placed in storage drums and ***label the drums***.
- Keep incompatible materials separate.
- Turn in full drums to HazMat Storage Area with list of contents and MSDS's.

Prior to Disembarking:

- Police area for remaining HazMat.
- Return unused drums to HazMat Storage Area.
- Turn in all remaining HazMat to Storage Area.

HazMat Spills:

- Contact Fire Department: location, type of material, amount of spill.
- Contain spill if possible.
- Evacuate area.
- Contact HazMat Team for spill response.



USAF Civil Engineering Contacts:

Pre-Employment (Prior to 13 Sep 95)

1 Lt Erik Larson
HazMat Team OIC.....Voice DSN: 787-6964
Fax DSN: 986-1595
E-Mail: larsone@wrightpatterson-de.af.mil

SSgt Thomas Wilson
HazMat Team NCOIC......... DSN: 787-3904

Bright Star AB (15 Sep 95 - 8 Dec 95)

1 Lt Erik Larson
HazMat Team OIC....***Call Bright Star witchboard, ask for USAF Civil Engineering.***

SSgt Thomas Wilson
HazMat Team NCOIC................***Same as above.***

Hazardous Materials and Waste Management Guidance

Bright Star 95

Appendix B

Recurring Acronyms

AFCEE	Air Force Center For Environmental Excellence
AFCESA	Air Force Civil Engineering Support Agency
AFSC	Air Force Specialty Code
BSP	Base Support Plan
COB	Collocated Operating Base
CONUS	Continental United States
DOT	Department of Transportation
DRMO	Defense Reutilization and Marketing Organization
EPA	Environmental Protection Agency
FAC	Functional Account Code
FGS	Final Governing Standards
HazMart	Hazardous Materials Pharmacy
HCS	Hazardous Communication Standard
HWAP	Hazardous Waste Accumulation Point
JCS	Joint Chiefs of Staff
MSDS	Material Safety Data Sheet
NEPA	National Environmental Policy Act
NSN	National Stock Number
OEBGD	Overseas Environmental Baseline Guidance Document
OSHA	Occupational Safety and Health Agency
Prime BEEF	Base Engineer Emergency Force
RCRA	Resource Conservation and Recovery Act
SOFA	Status of Forces Agreement
TPFDL	Time Phased Force Deployment Listing
UCMJ	Uniform Code of Military Justice
UTC	Unit Type Code
WMP	War Mobilization Plan
WRM	War Reserve Materials

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Vita

Captain Christopher J. West was born on 24 December 1968 in Charlotte, North Carolina. He grew up mainly in Boone, North Carolina and Auburn, Alabama as his family moved back and forth between the locations. He graduated from Auburn High School in 1987 and attended Auburn University on an Air Force ROTC scholarship. He graduated as a Bachelor of Electrical Engineering in 1991 and was commissioned as a 2nd Lieutenant in the Air Force. He began his Air Force career at Cannon AFB, New Mexico where he served as both a project manager and maintenance engineer for two years in the 27th Civil Engineer Squadron. In May of 1994, he was assigned to the 554th RED HORSE Squadron at Osan Air Base, Republic of Korea, where he served as project engineer. In May of 1995 he was selected to attend the Air Force Institution of Technology as part of its General Engineering and Environmental Management Program. Upon his graduation and completion of the program in January 1997, he will be assigned to the 347th Civil Engineer Squadron at Moody AFB, Georgia where he will fill the position of environmental flight commander.

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13. ABSTRACT *(Maximum 200 words)*

Increased awareness of the potential for adverse mission impact on deployments, recent experience, and staff interest establish the need for a hazardous materials and waste management system for contingency environments. This research was focused toward establishing a basis for developing such a system. An intensive literature review was accomplished to justify the research, characterize the contingency environment, review regulatory requirements, review proper hazardous substance processing procedures, and review material resources which may be employed in such a system. Further review led to the development of a design methodology for producing such a basis. Employment of the methodology in characterizing the problem, generating and screening alternatives, and grouping of surviving alternatives established a basis for future specification of a management system for contingency deployments. A final recommendation to the Air Force was made which included the coordinated adoption of the management system by Air Staff representatives of the various functional components of a deploying wing. The staffing support of these functions at the Air Staff, Major Command, and support agency level could then take the recommended practical implementation measures.

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